POWER PLANT ENGINEERING

Established Over 28 Years

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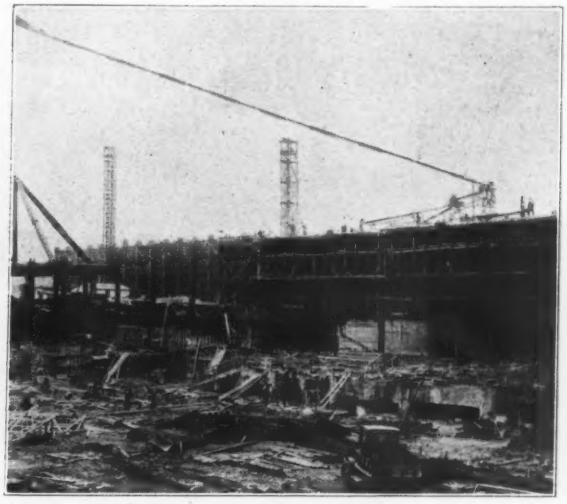


Nature's Methods Would Take Ages

WHAT NATURE has given us in the way of building stone she has taken thousands upon thousands of years to prepare. Her products are, without question, marvels of strength and beauty but as she leaves them they serve man only as a crust about the earth upon which to stand. To serve his purposes, man now makes his own stone. He makes it strong by embedding steel in it. He makes it homogeneous, every inch dependable, leak proof and fire proof. He forms it to suit every conceivable need in building construction. Man's process requires only a few hours from the plastic state to the flint-hard mass. Although this necessity in our industrial life is simple to make, the proportioning of the ingredients must be done with great care as explained in the article, Mixing Concrete for Power Plant Use, which appears in this issue.

CALLING UPON a piece of equipment to go in and out of service automatically is nothing new in the power plant but to expect a motor to select automatically the one most important service which it should perform among the four of which it is capable seems like investing machinery with human intelligence. This, however, is exactly what is done in a New England mill where a synchronous motor is so hooked up that it will serve as an auxiliary to either a steam engine or turbine, as a power-factor booster or as an emergency power unit for either of two mills. Just how this is done is explained on page 1005.

Municipal Service for Muscatine

PUMPING STATION IS NUCLEUS FOR POWER PLANT WHICH STARTS OPERATION WITH MOST MODERN EQUIPMENT

ON JUNE 1 the city of Muscatine, Iowa, located in the southeastern part in the state on the Mississippi River, put into operation a municipally owned electric light plant which will furnish electricity for public service in competition with the existing public service company, a subsidiary of the United Light and Railways Co., and in addition will handle all the street lighting and pumping requirements of this industrial city of 17,000 inhabitants. The city owns and operates a water works system and the new municipal electric light plant is located at the site of the water works station which is approximately 2½ mi. south of the business district of the city. The old water works building and the new power plant building are connected so as to provide combined operation. Connections are so made in the equipment as to provide emergency water works service and flexibility in operation. Current generated in the power plant is transmitted to a sub-station located near the center of the city where the voltage is reduced and from which distribution is made to all its customers.

In the power plant are two 750-kw. turbo generating units and two 314-hp. water-tube boilers. Sufficient space is provided, however, for an additional generating unit of 1500 kw. capacity and a boiler of 500 hp. when load conditions warrant their installation. The design of the plant is worked out for an ultimate capacity of 6000 kw.

Although located near the bank of the Mississippi River which would naturally be considered as the source of condensing water, the supply used for this purpose comes from wells which furnish the water for the city. This source of supply has several advantages over the river in that with the same suction head on the pumps, the water is free from all sediment, trash and fish without the necessity of providing a screen or filter; the temperature varies but little the year round, being considerably lower in summer than that of the river; and the initial cost of sinking the two additional wells required is much less than that of constructing an intake tunnel with rack.

MONORAIL HANDLES COAL AND ASHES

Coal comes to the plant in railroad cars and is unloaded by means of a 3-T. monorail carriage and hoist. From the storage space a monorail track 510 ft. long is provided for delivering coal to the stoker hoppers. This coal handling equipment consists of an electrically operated carriage, hoist and clam shell bucket and a standard rocker dump steel ash car which runs on a 24-gage track in the boiler room basement and is picked up by the hoist for delivering ashes to the storage. The monorail track extends over the coal bunkers in the boiler room and runs outside over the 2000-T. storage space to the railroad track. This coal handling equipment is capable of handling 125 T. of coal a day to the stoker hoppers and was furnished by the Shepard Electric Crane & Hoist Co.

In the design of this system of coal handling the growth of the plant was taken into consideration and plans were made to install a bucket conveyor and apron feeder type of coal handling equipment when the additional boiler is put in. This will be located immediately outside the boiler room and carry the coal to overhead bunkers which will feed by gravity to the stoker hoppers. In the ultimate plan, the monorail system will deliver to a concrete pit from which the apron feeder will discharge the coal to the bucket conveyor. When this system has been installed, a steam jet ash conveyor will be used to deliver the ashes to railroad cars on a siding.

Boilers Deliver Steam at 538 Deg.

Steam is furnished for this plant by two Heine boilers designed for 200 lb. pressure and furnished with Foster superheaters which give the steam a superheat of 150 deg. These boilers are served by Westinghouse underfeed stokers, each having four retorts and side-wall tuyeres. Copes regulators control the supply of feed water to the boilers direct from the boiler feed pumps. Other mountings for each boiler consist of one Ashton steam gage with 12-in. dial, one Reliance water column with three trycocks, one combination drum head and check valve for feed line operated from the floor, one straightway and one angle type combination blowoff valve and two Lagonda 4½-in. pop safety valves.

Boiler blowoff piping is extra heavy, lap welded, wrought steel except that cast-iron pipe is used for the 6-in. outlet from the blowoff tank. Each bottom blowoff connection is equipped with a 2-in. gate valve nearest the boiler and a 2-in. Everlasting rack and pinion operated blowoff valve outside the gate valve. Each surface blowoff connection is equipped with two 1½-in. gate valves and each superheater blowoff connection is equipped with a ¾-in. gate valve in each branch and a ¾-in. gate valve in the down pipe leading from the superheater. The blowoff tank is of wrought steel having a capacity of 100 cu. ft., the shell being ⅜-in. in thickness.

FIG. 1. FROM THE BOILER ROOM, THE MONORAIL COAL CARRIER RUNS AROUND THE END OF THE PUMP BUILDING TO THE RAILROAD TRACKS

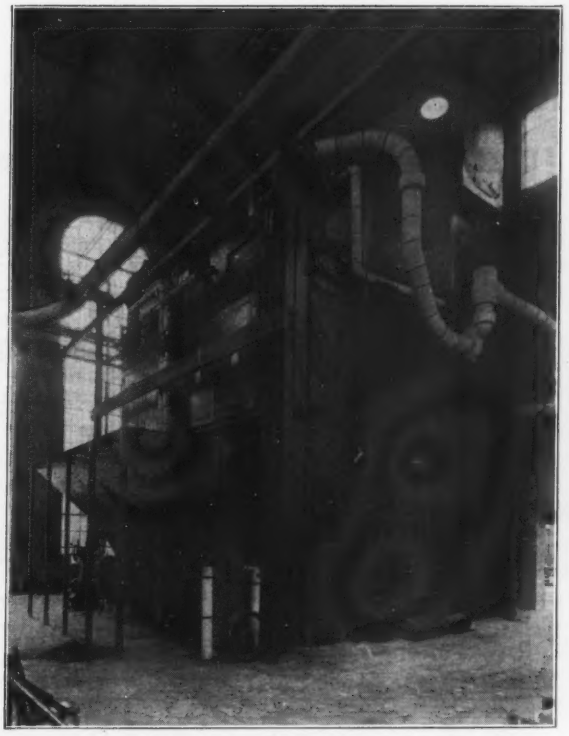


FIG. 2. AIR TIGHT INSULATING COVERING PREVENTS AIR LEAKAGE THROUGH THE BOILER SETTING

Attached to the furnaces are Ellison draft gages giving the wind box pressure and differential draft between furnaces and stack. The stokers are provided with steam operated ash dump gates and Diamond Valv-in-head soot blowers of seven units are used for dusting the boiler tubes.

Each boiler is furnished with a superheater which is designed so as to superheat 1600 lb. of steam per hour from the temperature of saturated steam at 200 lb. gage pressure to a total temperature of 538 deg. F. or a differential of 150 deg. F. The equipment for the boiler consists of the superheater proper, the connecting pipes and flanges, one superheater pop safety valve, a set of cleaning, dusting and access doors, drain pipes, valves and connections.

Furnace Has Large Combustion Space

The combustion chamber has approximately 900 cu. ft. contents. The height of the lower row of tubes is 12 ft. above the floor line and the furnace width is sufficient to accommodate a four-retort underfeed stoker. The baffling is of the diagonal type with T tile on the second row of tubes. The two lower rows are arranged on rectangular centers so that the T tile may be inserted from the furnace chamber. The outside walls of the setting are 22 in. in thickness and these are lined with 13 in. of fire brick. The division wall, 26 in. thick, and the bridge wall, 22 in. thick, are built of solid fire brick.

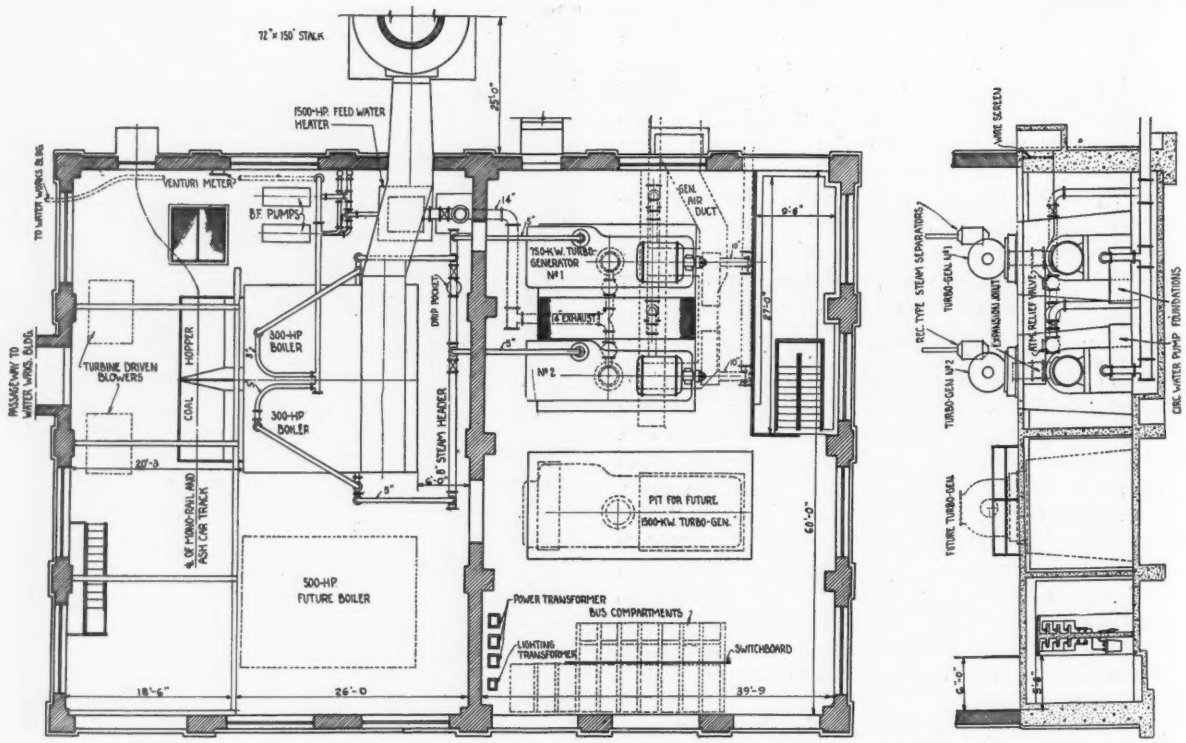


FIG. 3. PLANS OF THE PLANT PERMIT DOUBLING ITS PRESENT CAPACITY WITHOUT ADDITION TO THE BUILDING

One of the special features of this boiler setting is the manner of insulating the exterior of the brick walls. Wire loops are inserted in the red brick setting, every sixth course. Three coats of coal tar boiled to thin consistency and with asbestos wool stirred in it are then applied to the brick surface. After the mixture has thoroughly dried, a plastic asbestos cement is applied 1¼ in. thick. Over this, chicken wire of 2-in. mesh is stretched and securely tied to the wire loops in the brick work. Then another coat of asbestos cement ¾ in. thick is applied and after this has dried, the entire surface is covered with 10-ounce canvas tightly pasted down and fastened by metal clips to the steel work of the setting. Two coats of asphalt paint are then applied.

Tops of the boilers and blank faces of the front and rear headers are insulated with Johns-Manville fire felt. Sheets 1 in. thick followed by a 2-in. layer of sponge felted sheets and three ¼-in. layers of cement. The ends of the drums are insulated with 85 per cent magnesia blocks 2 in. thick firmly wired on. Joints between blocks are filled with magnesia plastic and the surface covered with three layers of hard finished cement, the last layer being reinforced with chicken wire and covered with canvas jacket pasted on.

Underneath the boiler is a reinforced concrete ash pit constructed so that when the stoker dumps the ashes fall directly into the pit and slide toward the front wall which is in line with the boiler front and the sides and bottom slope toward the steel door. The ashes are removed by opening the door and scooping them into an ash car. The pit floor and walls are lined throughout with fire brick laid up with fire clay. Four drains are provided for each ash pit which are connected by cast-iron soil pipe to a common outlet connected to the floor drain of the building. On the front and two side walls of the ash pit, a 1-in. galvanized water pipe is provided, drilled with ⅛-in. holes spaced 3 in. apart. This pipe serves as a sprinkler system for quenching the ashes.

As previously stated, the boilers are served by Westinghouse underfeed stokers. The furnace width is approximately 7 ft. and the stack serving the boiler is 150 ft. by 6 ft. Each stoker is furnished with an extra large hopper, having sufficient capacity for a 5-hr. run at 200 per cent rating and revolution counters are provided to keep fairly accurate account of the coal burned.

Each stoker is separately driven by a steam engine made by the E. H. Wachs Co., but the two stoker shafts are interconnected through a clutch so that either engine can operate either or both stokers. The steam pressure supplied these engines is 200 lb. gage and 150 deg. superheat. They exhaust against a back pressure of 2½ lb. during the heating season. These engines are fully enclosed and self-lubricating. They are connected to the main steam header and exhaust into the feed-water heater.

Coal used in the plant is mined in Illinois and has the following approximate analysis:

37.07 per cent fixed carbon
38.27 per cent volatile matter
9.70 per cent ash
15.00 per cent moisture
3.75 per cent sulphur and a heating valve of
9500 B.t.u. per lb. as fired.

The stokers are designed with sufficient capacity to burn enough coal to develop 175 per cent of the normal rated horsepower of the boiler continuously and a maxi-

mum of at least 225 per cent of normal rating for a period of 2 hr.

Two forced draft fans manufactured by the Buffalo Forge Co. and driven by Westinghouse turbines are installed in the basement of the boiler house and used for supplying air to the stokers. Each fan is of sufficient capacity to supply air for all requirements of the two stokers when the boilers are operated at 225 per cent of their normal rated capacity. The blowers are designed for a static pressure of 5½ in. and are of the multi-blade type, three-quarter housed, with vertical discharge. There is provided a tight closing damper for closing the discharge opening of each fan when the fan is not in operation. Clean-out doors are also provided to facilitate the quick cleaning of the fan blades.

Stack Is of Reinforced Concrete

Serving the two boilers which are installed in this plant is a reinforced concrete chimney which was built by the Webber Chimney Co. It is built upon a concrete foundation and has a total height of 150 ft. above the ground line and an internal diameter of 6 ft. An expansion lining of radial fire brick is provided which is 4½ in. thick and 50 ft. high above the cinder door. The fire brick is laid up with fire clay and the lining is separated from the shaft proper by an air space of 2 in.

Protection against lightning is provided for by means of a lightning conductor having four points at the top connected together and to the ground by a copper cable. The chimney is also provided with a ladder which is constructed on the outside and extends from the bottom to the top. A heavy cast-iron, clean-out door near the bottom is also provided. Its dimensions are 24 by 36 in. and it is hung on hinges.

Connecting the uptake outlets of the two boilers with the chimney is the boiler breeching which is provided with clean-out doors and expansion joint supports. It is made of No. 8 B. W. gage sheet iron with lap joints securely riveted and asbestos packing is used around the breeching where it passes through the walls of the building and stack.

Heating the Feed Water

Located at one end of the boiler room are the open feed-water heater and two boiler feed pumps. This heater is designed for use in connection with the auxiliary equipment exhausting at a pressure not to exceed 2½ lb. It was manufactured by the Cochrane Corp. and has sufficient capacity to supply 45,000 lb. of feed water per hour at a temperature of 210 deg. F. when supplied with 6000 lb. of exhaust steam at atmospheric prsesure and the cold water supply at a temperature of 65 deg. F. The normal capacity is 20,000 lb. of feed water when supplied with 3000 lb. of steam under the same conditions as given above.

Exhaust steam enters the heater through an oil separator of sufficient capacity to remove all the oil from 6000 lb. of steam per hour. This separator is of the self-cleaning type and is provided with a separate trap to discharge the oil and entrained moisture. The cold water enters the heater through an automatic balanced valve controlled by a ventilated copper float. The pump suction opening is protected so as to prevent impurities or scum from entering the feed pump, and as an additional precaution, a Lagonda multiple filter is provided between the heater and the pumps.

Insulation for the heater and all pipes for steam and hot water is of 85 per cent magnesia covering 1½ in. thick, the heater being insulated with magnesia blocks wired in place, the joints being filled with magnesia plastic and the surface covered with hard finished cement trowelled smooth.

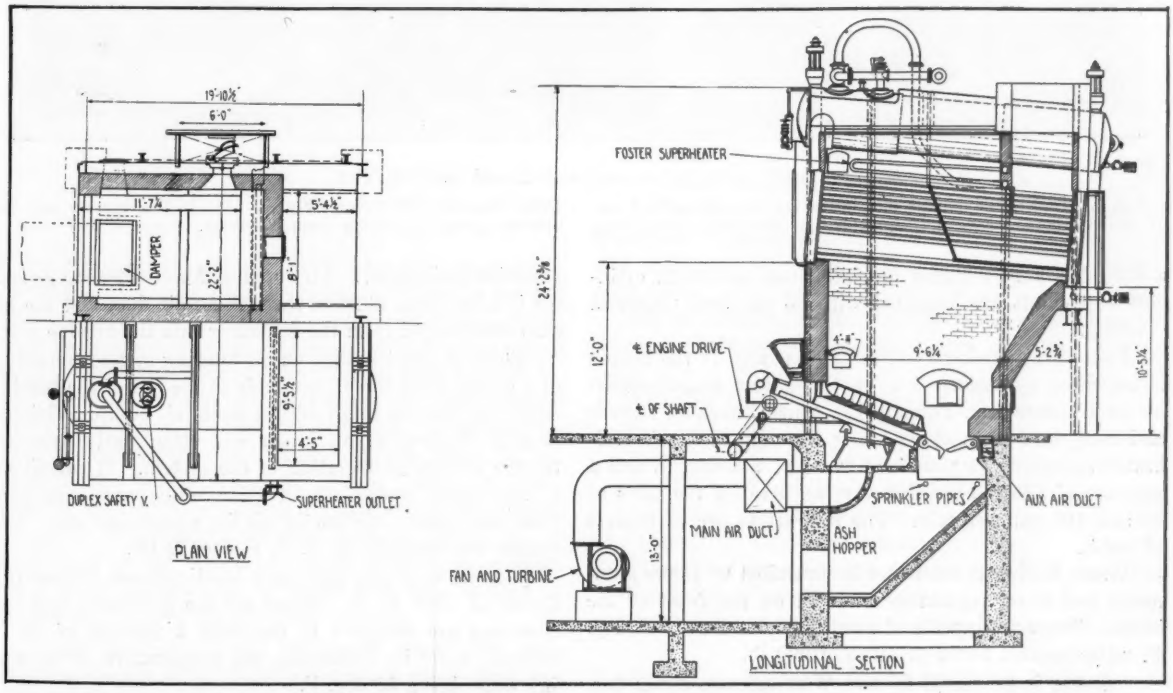


FIG. 4. CROSS SECTION OF BOILER SHOWS LOWER ROW OF TUBES COMPLETELY EXPOSED TO RADIANT HEAT OF FURNACE

Two boiler feed pumps are provided, these being manufactured by the Platt Iron Works and are of the horizontal duplex, double-acting, outside end packed, steam-driven, direct-acting type with balanced piston valve steam end and pot-valve water end, the dimensions being 9 by 6 by 10 in. They take steam direct from the boilers at 200 lb. pressure and 150 deg. superheat and are designed to handle the feed water at 212 deg. F. against a pressure of 225 lb. The pumps are controlled by Fisher pump governors with a steam bypass containing a globe valve provided to bypass the governor. Each pump is provided with a Hills-McCanna cylinder lubricator and the steam cylinders and chests are insulated with 85 per cent magnesia covering.

Feed water passing from the feed pumps to the boilers is measured by means of a Venturi meter manufactured by the Builders Iron Foundry Co. which indicates, records and integrates the water passing through it. It is calibrated to register in pounds of water at 212 deg. F. and a pressure of 225 lb., the flow varying between the rates of 10 and 100 gal. per min. The indications are in pounds of water.

Water flowing to the boiler is controlled by Copes automatic feed-water regulators mounted on the front of the boiler. These are capable of passing 20,000 lb. of 210 deg. F. water against boiler pressure of 200 lb.

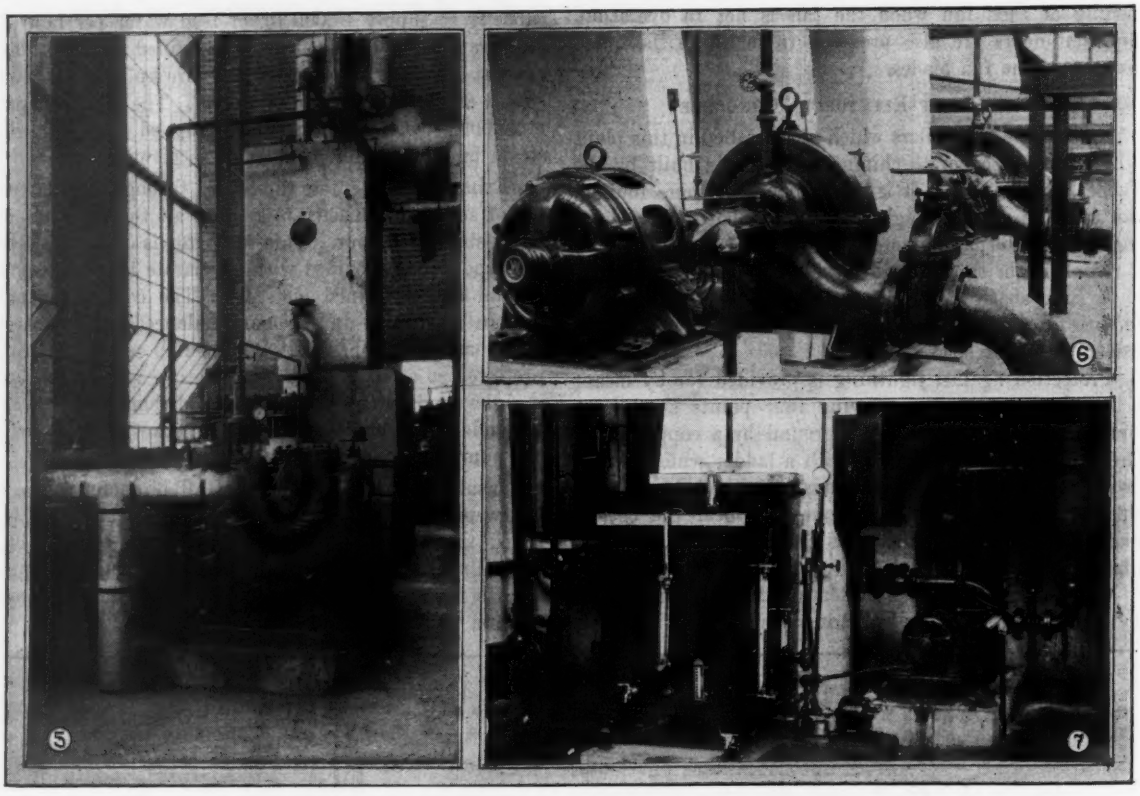
Current is generated by two Westinghouse steam turbine generating units of the combined impulse-reaction type. These each have a capacity of 940 kv.a. generating 3-phase, 60-cycle alternating current at 6600 v. The speed of the units is 3600 r.p.m. The exciters are direct connected to the turbine shaft and are rated at 18 kw. generating direct current at 125 v. Steam is furnished to these units at a pressure of 200 lb. and 150 deg. superheat.

There was supplied with each generating unit, a synchronizing motor with necessary equipment for varying the speed of the turbine manually from the switchboard so as to synchronize the two turbine generating units. The gages supplied with each unit consist of a steam pressure gage, throttle pressure gage, vacuum gage and a Biddle vibration tachometer. Air supplied for cooling the generator is taken from outside, through an air duct and the hot air is discharged from the generator into the turbine room.

There is also installed an oil filtering system consisting of a bypass from the oil reservoir in the bed of the turbine, sight overflow, oil filter, duplex steam oil pump, a Griscom Russell Multi-whirl oil cooler and other parts necessary for the successful operation of the system. It constitutes a continuous system of filtration which will distribute, filter and clarify lubricating oil for continuous use. This system was supplied by S. F. Bowser & Co.

Serving each generator is a Westinghouse surface condenser of 1500 sq. ft. These are the horizontal two pass type and are designed to maintain a vacuum of 28 in. referred to 30 in. barometer, the temperature of the cooling water being 55 deg. F.

Circulating water for the condensers is taken from two 12-in. drilled wells, 50 ft. deep, located adjacent to the



PLANT AUXILIARIES ARE CONVENIENTLY LOCATED

Fig. 5. Boiler feed pumps and heater are in well-lighted end of boiler room. Fig. 6. Motor-driven condenser circulating pumps handle well water. Fig. 7. Oil filtering system and condensate pump in turbine room basement.

plant. Each well is capable of yielding 1½ million gallons of water a day. Between the turbine and the condenser is an expansion joint made of copper.

Two Westinghouse centrifugal circulating pumps are provided, each of which has a capacity of 1250 gal. per min. These are driven at 600 r.p.m. by induction motors of 25 hp. capacity. The condenser pit floor level is 20 ft. above the extreme low water level and will average 18 ft. The total static head on the pump is approximately 30 ft. They take water direct from the wells and the discharge from the condensers goes to the river in cast-iron pipe laid 6 ft. under ground. These pumps are of the horizontally split type and so arranged that the revolving and working parts can be quickly removed without disconnecting the entire pump.

The condenser air pump is of the Westinghouse Leblanc type, motor driven, and the condensate pump is also of Westinghouse make and delivers the condensate from the condenser to the feed-water heater located in the boiler room. Owing to the fact that the air pump discharge can operate against practically no head and during the high water season, which is from three to six weeks each year, the basement is below the water level of the river, it was necessary to provide an auxiliary water tank, which is made of concrete and located in the basement, for recirculation of air pump water. All of the motors for the condenser auxiliaries have automatic push-button controls.

Steam Piping Designed For 225 Lb.

In general, the piping scheme for the steam supply consists of the following:

Two—5-in. lines from the boiler nozzles to the superheaters.
Two—5-in. lines from the superheaters to the main steam header.
One—8-in. steam header.
Two—5-in. lines from the main steam header to the turbine throttles.
One—5-in. line connecting the two boiler nozzles and the header from steam pumps in the old building.
One—5-in. auxiliary header connecting main header to boiler feed pumps, stoker engines, fan turbines and other plant auxiliaries.

All these mains and branches carry the superheated steam except the 5-in. pipe to the steam pumps in the old water works building which is connected to tees at the boiler nozzles and supplies saturated steam to the steam pumps. The entire piping system is designed for 225 lb. steam pressure and 150 deg. superheat. All steam supply pipe is extra heavy of mild wrought steel. Pipe 2 in. or larger is lap welded. All fittings of more than 1½ in. diameter are extra heavy flanged of open hearth cast steel, while the smaller sized fittings are used on all pipes 2 in. or larger. Pipe flanges for sizes 4 in. or larger are of forged steel of the Van Stone type, while those smaller than 4 in. in diameter are of forged steel forge welded to the pipe and finished all over after welding.

Gaskets used are of soft corrugated steel. For pipe joints less than 2 in. in diameter, screwed connections are used. All high pressure steel piping was manufactured by Geo. Limbert of Chicago.

At each boiler outlet is placed a 5-in. extra heavy triple automatic stop and non-return valve of Lagonda make. Globe valves are of extra heavy hard metal throughout. A gate valve is provided in each branch to a stoker engine or feed pump and in the supply line of the steam turbine driving the fan conveniently located above the main floor. Gate valves are placed in each drain branch and in all other small branches.

All pipe, fittings, valves, flanges, receivers, separators, traps, soot blower and drip piping is insulated, jacketed with canvas and finished with metal bands. All pipe 2 in. or larger is covered between flanges with fire felt 1 in. in thickness followed by a layer of sponge felt having a thickness of 2 in. for pipes 4 and 5 in. in diameter and 1½ in. for pipes 2 to 3 in. in diameter. Smaller pipes except drip line are insulated with 2 in. of sponge felt. Drip pipes are insulated with 1½ in. of 85 per cent magnesia.

All insulation is finished with 8-ounce canvas jackets pasted and sewed on and provided with black Japanned bands, 18 in. centers.

In the supply line lead to each turbine a receiver separator is provided and a separator is also placed in the supply lead to each steam turbine fan. The receiver separators for the two turbines have a capacity of 10 cu. ft. each and those for the turbine fans 2 cu. ft.

For the condensing apparatus a complete system of atmospheric relief piping is provided and a complete free exhaust system leading to the feed-water heater for all non-condensing apparatus. A 10-in. atmospheric relief valve for the steam turbines is furnished. The main atmospheric exhaust pipe is 14 in. in diameter and leads upward through the boiler room roof terminating in a cast-iron exhaust head. A 14-in. back-pressure valve which maintains a pressure on the heater and heating system is installed in this line.

Main Switchboard Has Hand Remote Control Switches

In one end of the turbine room is located the power station switchboard. It is designed for 6600-v., 3-phase, 60-cycle current characteristics and is of hand remote controlled type, equipped with Westinghouse instruments, the high voltage equipment, busses and wiring being located in the basement and the measuring instruments, control apparatus for power switches and rheostats and the panels with only low voltage wiring is located on the turbine room floor.

The switchboard consists of 11 panels controlling the circuits as follows and installed in the following arrangement:

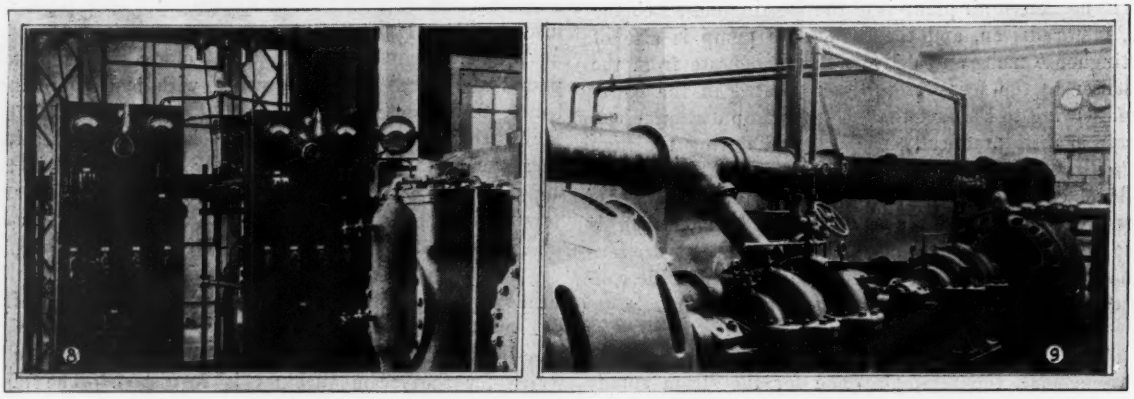
Swinging bracket and instruments.
Panel No. 1—750 kw. 6600 volt, 3-phase generator.
Panel No. 2—750 kw. 6600 volt, 3-phase generator.
Panel No. 3—blank for future generator.
Panel No. 4—exciter panel.
Panel No. 5—exciter panel.
Panel No. 6—automatic generator voltage regulator.
Panel No. 7—totalizing panel.
Panel No. 8—6600 volt, 3-phase feeder panel (1500 kw.)
Panel No. 9—blank for future feeder as No. 8.
Panel No. 10—synchronous motors for waterworks.
Panel No. 11—station equipment.

Electric supply to the building is furnished by the primary current at 6600 v., 60 cycle and is transformed to 220-110 v. for house service. The secondary connection from transformer to distributing panel is of No. 2 B. & S. gage R. C. copper wire and run in 1½-in. conduit. The house transformers are located in the basement and consist of three supplying the power circuits each of 25 kv.a. capacity and a voltage ratio of 6600 to 220 connected in 3-phase delta-delta. One lighting transformer is provided with a capacity of 10 kv.a. and a ratio of 6600 to 110/-220 v. These were all furnished by the Pittsburgh Transformer Co.

Two synchronous motor panels in the water works building are provided, each to control and operate a 200-kv.a., 6600-v., 3-phase, 60-cycle, synchronous motor at varying power factors from 70 to 90 per cent. The two panels are mounted together and supplied with current from the main switchboard panel. These are supplied by the Electric Machinery Mfg. Co. of Minneapolis, Minn., and have a rating of 196-hp. continuous duty. They are designed for push button control of the two synchronous motor-driven centrifugal pumps which supply the city with water.

City water is pumped at this plant by two DeLaval two-stage centrifugal pumps designed to operate at 1800 r.p.m. against a head of 131 ft. delivering 1800 gal. per min. These are driven by synchronous motors furnished by the Electric Machinery Co. which are rated at 196 hp., 200 kv.a., 6600 v. excitation being furnished by a direct connected generator of 4 kw. capacity delivering direct current at 125 v. These motors will correct the power factor of the plant from 75 per cent lagging to 90 per cent lagging when the external load on the plant is 1500 kw.

These pumps are located in the old pumping plant and take the place of two reciprocating pumps of the steam-driven type which are still held in reserve with steam connection to the new boiler plant.



SYNCHRONOUS MOTOR-DRIVEN PUMPS IMPROVE POWER FACTOR

Fig. 8. Switchboards for control of pump motors. Fig. 9. City water is pumped by synchronous motor-driven centrifugal pumps under push-button control. This equipment is located in the pumping plant and helps to maintain a high power factor.

Features of Building Construction

In the construction of the power house building, reinforced concrete and brick were used. The concrete foundation walls and basement floors of the building are water proofed being composed of one volume of cement and six volumes of aggregate. All other foundations and the footings consist of one volume of cement and eight volumes of aggregate. The construction is such that the highest known water level will not interfere with operation.

Waterproofed reinforced concrete is also used for the roof, the slabs being 3½ in. thick with ½ in. back plaster applied on the under side. On top of the concrete slab is placed a 2½-in. hollow gypsum block covering for insulation purposes and over this is laid a 5-ply Johns-Manville roofing.

For heating the building, steam is taken from the main exhaust in the boiler room, but in case of necessity, may be supplied through a live steam connection on the 3-in. auxiliary steam line. This connection consists of a gate valve and pressure reducing valve to reduce from 200 lb. pressure 150 deg. superheat to a proper heating pressure.

In connection with the heating system, an automatic pump and receiver set is used to elevate the condensate from the heating system and auxiliary exhaust system to the feed-water heater.

Cast-iron sectional type radiators are used, having three columns 38 in. high in the basement and 30 in. high on main floors. The following is the radiation which is provided in the different rooms of the power plant:

Room	No. Radiators	Total No. Sq. Ft.
Turbine	10	3000
Boiler	10	4000
Turbine basement and switchboard room	8	800

Floor grating in the turbine room is of Irving subway and the stairways are made of similar material. Over all pipe trenches checked cast-iron floor plates ¼ in. thick are provided. These are ribbed, supported by iron channels and fit closely to the floor.

In the turbine room a 15-T. Whiting overhead traveling crane is provided. Hoist, truck and bridge are all operated by hand power by pendent chains reaching to within 3 ft. of the floor.

Construction and operation of this plant is carried on under the supervision of the "Board of Electric Light Trustees" consisting of J. L. Giesler, Arthur Hoffman and B. C. Benham, J. E. Tuttle being the superintendent of the plant. The entire plant and system was designed and supervised by Arthur L. Mullergren of Kansas City, Mo., who was the consulting engineer for the city of Muscatine.

Calculation of the Boiler Heat Balance

Solution of a Problem and an Analysis of Conditions Which Affect Boiler Economy Over Various Periods of Operation

BOILER TESTS ARE conducted for several reasons, the first being that of checking up on the guarantees as specified at the time that new equipment was purchased and the second reason being for the purpose of studying the operation with the point in view of improving economy.

The calculation of a boiler test does not give an itemized account of the individual items of boiler operation wherein losses occur. It is necessary, therefore, to resort to the calculation of a heat balance which is based upon the data gathered at the time of the boiler test. The heat balance shows in detail where the various losses have occurred and is, therefore, extremely valuable in finding those items which are out of line and which should be corrected in order to improve economy.

Boiler operation losses may be readily classified into two groups, those which are unavoidable and those which may be controlled. The unavoidable losses result directly from the necessity of discharging the gas of combustion at a temperature above that of the fuel and from the moisture and hydrogen content of the fuel. Those losses which may be controlled result from the amount of air used in excess of that necessary for the complete combustion of the fuel; unconsumed combustible matter wasted in the ash; unconsumed gaseous combustible discharged with the

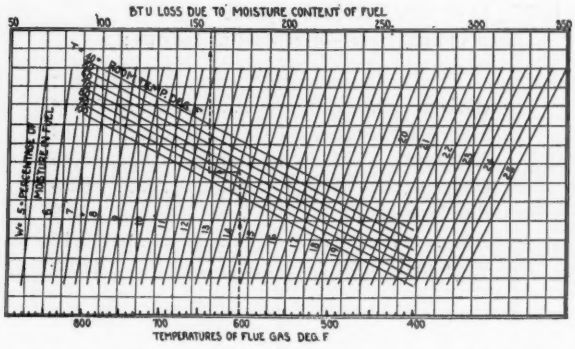


FIG. 1. CHART FOR DETERMINATION OF B.T.U. LOSS DUE TO MOISTURE CONTENT OF FUEL

Enter chart at base line at the temperature of the flue gas, follow up to room temperature, then horizontally to line representing percent moisture in fuel, then read vertically up to top scale, which is the loss in B.t.u.

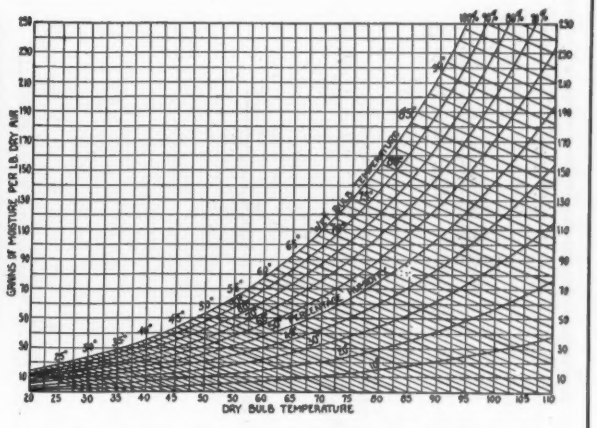


FIG. 3. CHART SHOWING GRAINS OF MOISTURE PER POUND OF DRY AIR

Locate dry bulb temperature on bottom line, follow up to intersection with wet bulb temperature diagonal line, then horizontally, right or left, to grains of moisture per pound of dry air.

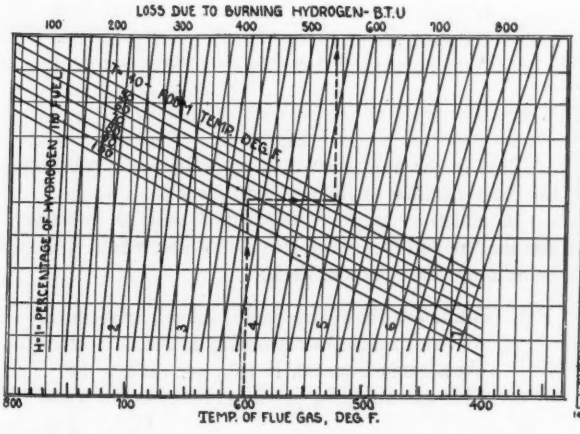


FIG. 2. CHART SHOWING B.T.U. LOSS DUE TO BURNING HYDROGEN

Locate flue gas temperature at bottom of chart, follow up to line representing room temperature, then horizontally to line representing per cent hydrogen in fuel, then vertically up to the top line, which shows loss in B.t.u.

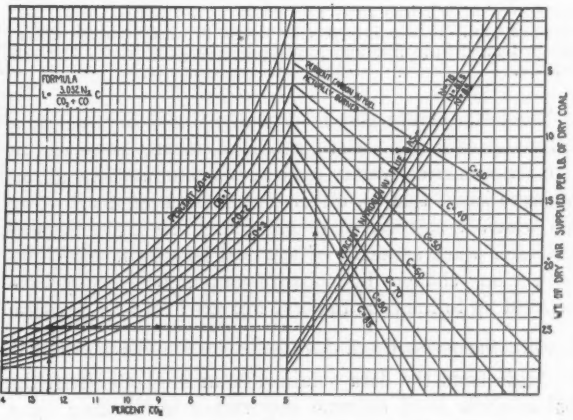


FIG. 4. CHART FOR DETERMINATION OF WEIGHT OF DRY AIR SUPPLIED PER POUND OF DRY COAL

Enter chart at base line showing CO_2, follow up to curve representing per cent CO, then horizontally to diagonal line representing per cent nitrogen in flue gas, then vertically to line representing carbon in fuel and finally horizontally to right-hand margin.

exit gas and finally the heat loss through radiation from the boiler setting and the furnace walls.

As ordinarily listed, the items given in a heat balance are as follows:

1. Loss due to the moisture content of the fuel.
2. Loss due to the water vapor formed by the combustion of hydrogen.
3. Loss due to the moisture in the air used for combustion.
4. Loss due to the heat carried away in the dry chimney gas.
5. Loss due to unconsumed solid combustible matter (combustible in refuse).
6. Loss due to incomplete combustion of gaseous combustible matter discharged with the chimney gas.
7. Radiation and unaccounted for losses.

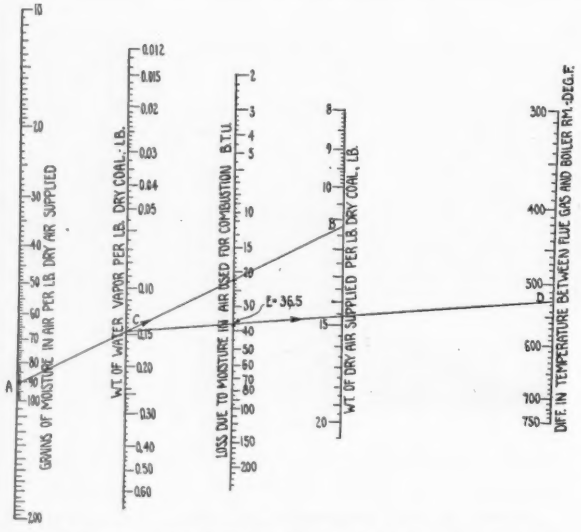

GRAINS OF MOISTURE IN AIR PER LB. DRY AIR SUPPLIED
WT. OF WATER VAPOR PER LB. DRY COAL - LB.
LOSS DUE TO MOISTURE IN AIR USED FOR COMBUSTION - B.T.U.
WT. OF DRY AIR SUPPLIED PER LB. DRY COAL, LB.
DIFF. IN TEMPERATURE BETWEEN FLUE GAS AND BOILER RM.-DEG.F.
A
C
D
E = 36.5

FIG. 5. LOSS DUE TO MOISTURE IN AIR USED FOR COMBUSTION, B.T.U.

Enter chart as at A, showing grains of moisture in air, draw line AB to fourth line from left which shows weight of air per pound of coal. Locate intersection C and draw CD to the difference in temperature line and locate point E which shows the loss in B.t.u.

The heat balance may be worked up on a dry fuel or a fuel as fired basis. Care must be taken, however, to have the numerical values used in the computations all on the same basis, that is, either on the basis of dry fuel or fuel which is as received or as fired. The latter term is preferable when speaking of wet coal because it takes into account any changes in moisture content which may have occurred up to the time the coal was fired into the furnace.

Transposing Coal Analysis to Proper Basis

Aside from the data obtained from the boiler test, the coal analysis is of extreme importance in working up a heat balance. The ultimate analysis is that which is required and it must be on the dry coal basis if that is the one being used.

Oftentimes an ultimate coal analysis will be reported on the basis "as received"; then, if it is wanted on a dry basis, the figures must be converted over to the latter. A typical ultimate analysis "as received" is as follows:

Carbon	57.36 per cent
Hydrogen	5.41 per cent
Nitrogen	1.05 per cent
Oxygen	18.02 per cent
Sulphur	4.76 per cent
Ash	13.40 per cent
	100.00

From a proximate analysis the free moisture of this coal would be about 11 per cent.

In this analysis the free moisture is included in the hydrogen and oxygen. Since water is composed of one part hydrogen and eight parts oxygen, 1/9 of the free moisture should be subtracted from the hydrogen and 8/9 from the oxygen in order to include free moisture as a separate item in the analysis.

Going through the calculations of this we would have $5.41 - 1/9 \times 11 = 4.18$ per cent hydrogen and $18.02 - 8/9 \times 11 = 8.25$ per cent oxygen.

Then the analysis would read as follows:

	Per cent
Carbon	57.36
Hydrogen	4.18
Nitrogen	1.05
Oxygen	8.25
Sulphur	4.76
Ash	13.40
Free moisture	11.00
	100.00

Now then to get this analysis to moisture free or dry basis we must divide each item in this last analysis tabulation by one minus the proportional weight of moisture, or by $1 - 0.11$, which equals 0.89. The ultimate analysis on a moisture free or dry basis will be:

Carbon	$57.36 \div 0.89 =$	64.44 per cent
Hydrogen	$4.18 \div 0.89 =$	4.69 per cent
Nitrogen	$1.05 \div 0.89 =$	1.18 per cent
Oxygen	$8.25 \div 0.89 =$	9.28 per cent
Sulphur	$4.76 \div 0.89 =$	5.36 per cent
Ash	$13.40 \div 0.89 =$	15.05 per cent
		100.00

This is the analysis which we will use in working up the heat balance on a dry fuel basis.

In addition to the foregoing it will be necessary to assume the following information which would ordinarily be obtained from actual data:

B.t.u. per lb. of dry coal	12,100
Ash and refuse, per cent dry coal	21
Unconsumed carbon in ash, per cent	30
Flue gas analysis, per cent CO_2	12.5
O_2	5.0
CO	0.6
N_2	81.9
Evaporation from and at 212 deg. F. per lb. dry coal, lb	8.8
Wet bulb thermometer, deg. F.	68
Temperature of boiler room, deg. F.	75
Temperature of exit gas, deg. F.	600

With this data we may now calculate or take from the charts the various losses in the order in which they have previously been stated.

(1) Loss due to moisture content of the fuel. The moisture content of the coal is 11 per cent which expressed in terms of dry coal is $11 \div (100 - 11) = 12.3$ per cent. The loss due to moisture can be expressed by the empirical formula:

Loss, B.t.u. per lb. $= W\ (1090.7 + 0.455\ T - t_f)$

where W equals the weight of moisture per pound of fuel, T equals the temperature of the flue gas and t_f equals the temperature of the fuel, which is the same as room temperature. Substituting in the formula we have—

$$\text{Loss} = 0.123\ [1090.7 + (0.455 \times 600) - 75]$$
$$= 158.5 \text{ B.t.u. or } \frac{158.5}{12{,}100} = 1.31 \text{ per cent}$$

(2) Loss due to burning of hydrogen. This may be expressed by the following formula:

Loss, B.t.u. per lb. $= 9H_2\ (1090.7 + 0.455T - t_f)$

where H_2 equals the weight of hydrogen per pound of fuel and T and t_f have the same values as before. Then the

$$\text{Loss} = 9 \times 0.0469\ [1090.7 + (0.455 \times 600) - 75]$$
$$= 544 \text{ B.t.u. or } \frac{544}{12{,}100} = 4.50 \text{ per cent}$$

(3) Loss due to moisture in the air used for combustion. From the wet and dry bulb thermometer readings and the psychrometric chart, Fig. 3, it is found that the grains of moisture in the air per pound of dry air supplied is 91, or $\frac{91}{7000} = 0.013$ lb. The weight of dry air supplied per pound of dry coal can be obtained from the formula $\frac{3.032\ N_2}{CO_2 + CO}$ C. By substitution we find that the dry air supplied $= \frac{3.032 \times 81.9}{12.5 + 0.6} (0.6444 - 0.063) = 11.20$ lb.

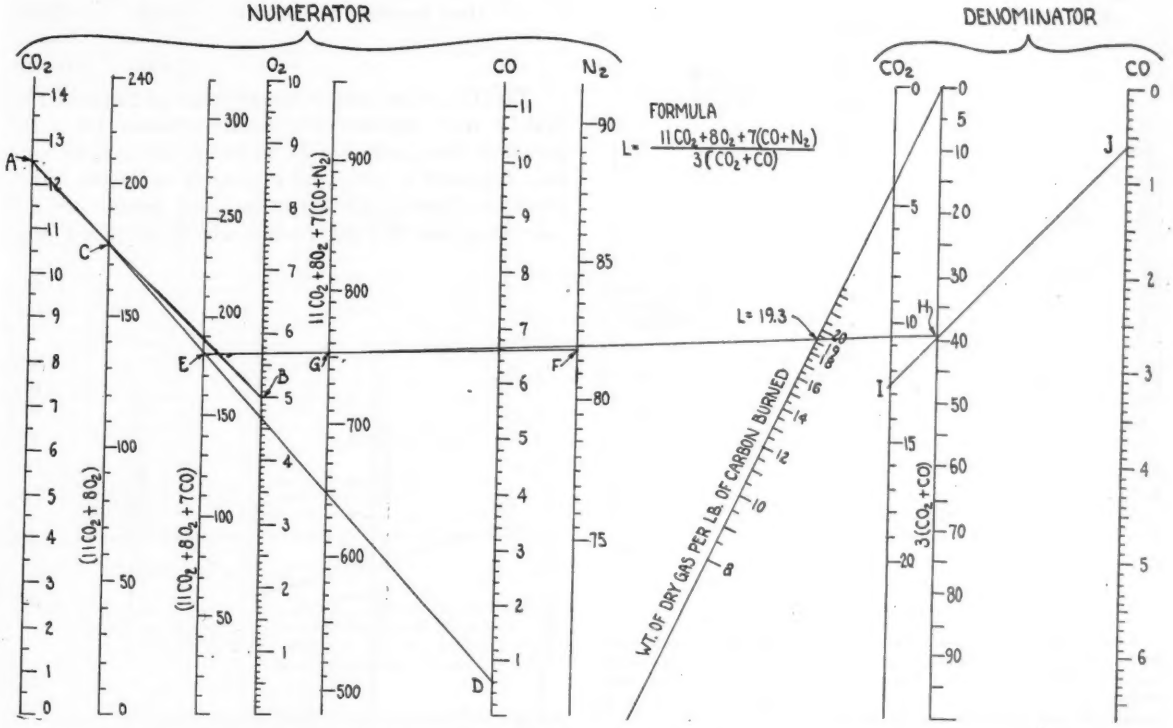


FIG. 6. CHART FOR DETERMINATION OF WEIGHT OF DRY GAS PER POUND OF CARBON ACTUALLY BURNED

Enter chart at A showing per cent CO_2, draw AB and note intersection at C. Draw CD to point on line representing CO and mark intersection E. Draw EF to point representing per cent nitrogen and mark intersection G. Then at right hand side of chart draw IJ and mark the intersection H. Finally draw GH and read the result at intersection L.

The weight of water vapor per pound of dry coal is $11.20 \times 0.013 = 0.145$ lb. and, therefore, the loss from this source is: $0.145 \times 0.48\ (600 - 75) = 36.5$ B.t.u. or $\frac{36.5}{12{,}100} = 0.30$ per cent. In the above expression 0.48 is taken as the specific heat of the water vapor which is present in the flue gas.

(4) Loss in the dry chimney gas. The weight of dry gas per pound of carbon burned can be obtained from the formula,

$$\frac{11\ CO_2 + 8O_2 + 7\ (CO + N_2)}{3\ (CO_2 + CO)}$$

By substitution we have:

$$\frac{11 \times 12.5 + 8 \times 5.0 + 7\,(0.60 + 81.9)}{3\,(12.5 + 0.60)} = 19.2 \text{ lb.}$$

The weight per pound of fuel will be 19.2 (0.6444 — 0.063) = 11.16 lb.

The loss due to the heat carried away in the dry chimney gas is then: $11.16 \times 0.24\,(600 - 75) = 1406$ B.t.u. or $\frac{1406}{12{,}100} = 11.62$ per cent. In the preceding expression the figure 0.24 is the mean specific heat of the flue gas.

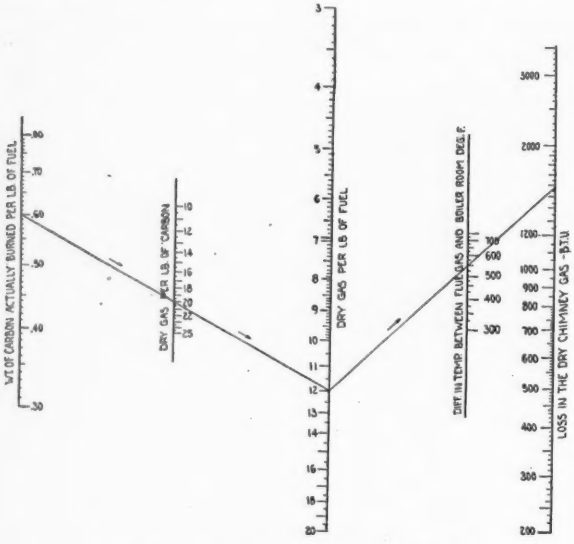

WT. OF CARBON ACTUALLY BURNED PER LB. OF FUEL
DRY GAS PER LB. OF CARBON
DRY GAS PER LB. OF FUEL
DIFF. IN TEMP. BETWEEN FLUE GAS AND BOILER ROOM DEG. F.
LOSS IN THE DRY CHIMNEY GAS - B.T.U.

FIG. 7. CHART SHOWING THE LOSS IN B.T.U. IN THE DRY CHIMNEY GAS

Enter chart on left-hand line. Draw line through point representing dry gas per pound of carbon. Extend this line to the center line. From this point draw a line through the point representing the difference in temperature. Extend this line to the right-hand and read the loss in B.t.u.

(5) The loss due to unconsumed combustible matter in the ash and refuse will be:

$$\frac{0.21 \times 30}{100} \times 12{,}100 = 762.3 \text{ B.t.u. or } \frac{762.3}{12{,}100} = 6.30 \text{ per cent}$$

(6) Loss due to unconsumed gaseous combustible matter will be:

$$\frac{0.60}{12.5 + 0.60} \times (0.6444 - 0.063) \times (10{,}160) = 270.5 \text{ B.t.u.}$$

or $$\frac{270.5}{12{,}100} = 2.24 \text{ per cent}$$

10,160 being the B.t.u. evolved in burning 1 lb. of carbon in carbon monoxide to carbon dioxide.

(7) Loss due to radiation and that loss which is unaccounted for is:

$$12{,}100 - (8540 + 158.5 + 544.0 + 36.5 + 1406.0 + 762.3 + 270.5) = 382.2 \text{ B.t.u. or}$$

$$\frac{382.2}{12{,}100} = 3.15 \text{ per cent}$$

Tabulating our results, we will have the following heat balance:

	B.t.u.	Per cent
(1) Loss due to moisture in fuel	158.5	1.31
(2) Loss due to hydrogen.....	544.0	4.50
(3) Loss due to moisture in air.	36.5	0.30
(4) Loss in dry chimney gas...	1,406.0	11.62
(5) Loss due to unconsumed combustible	762.3	6.30
(6) Loss due to unconsumed gaseous combustible.....	270.5	2.24
(7) Loss due to radiation, etc...	382.2	3.15
Heat absorbed by the boiler..	8,540	70.58
	12,100	100.00

This tabulation may represent either of two conditions: first, it may represent the results obtained for a short period of time, such as a 24 or 48 hr. test and, second, it may represent a period of a month's operation. If the latter, we should not expect as good results as if the calculation had been for a comparatively short test period.

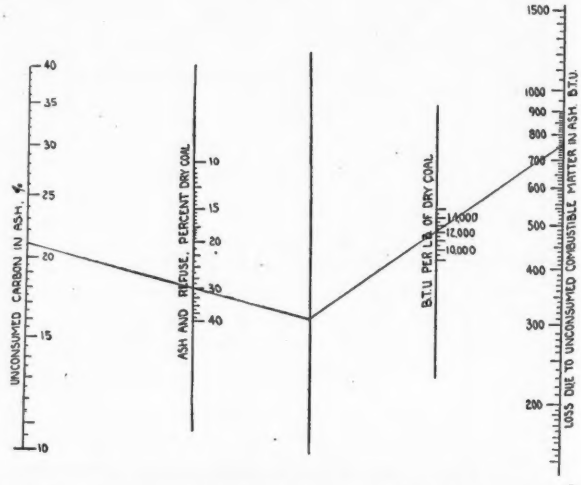

UNCONSUMED CARBON IN ASH, %
ASH AND REFUSE, PERCENT DRY COAL
B.T.U. PER LB. OF DRY COAL
LOSS DUE TO UNCONSUMED COMBUSTIBLE MATTER IN ASH B.T.U.

FIG. 8. CHART FOR DETERMINATION OF THE LOSS IN B.T.U. DUE TO UNCONSUMED COMBUSTIBLE MATTER IN THE ASH

Locate per cent carbon in ash on left-hand line and the per cent ash and refuse on the second line. Draw a line through these two points and extend it to the center line. From this point draw a line through the point representing B.t.u. per pound of dry coal to the right-hand line and read the loss in B.t.u.

If we stop to analyze this table we note first that the heat absorbed by the boiler, or the overall boiler efficiency is 70.58 per cent. This would be considered low for a test but would represent good average conditions for an extended period. The loss due to moisture in the fuel is uncontrollable unless it would be profitable to change the grade of fuel; or unless it were found that the operators were using an excessive amount of water in wetting down the coal. The loss due to hydrogen is a function of the hydrogen content of the fuel.

Loss due to moisture in the air is affected by the atmospheric conditions and the flue gas analysis. In our problem we may consider that the atmospheric conditions were about normal and therefore to cut this loss we must work toward an increase of CO_2. It is probable that this could be raised from 12.5 to 13.5 or even 14.0 per cent.

Loss in the dry flue gas is good average practice and would be lowered only by improved baffles or a more thorough cleaning of the water heating surfaces so that the flue gas temperature would be lowered. The loss caused by the unconsumed combustible in the ash is high. Evidently the fires were run too long or too deep. It indicates that a considerable amount of coke is carelessly being allowed to find its way into the ash pit.

careless use of blowoff valves, leaking valves, wasteful methods of blowing and cleaning tubes, safety valves which do not seat or which are allowed to blow without good reason are all ways in which a great amount of coal is wasted each year in the average boiler plant.

Careful analysis of the points outlined above, accurate tests and the calculation of the heat balance based on tests cannot fail to point out the mistakes which are so often made. The correction of these mistakes is but a determination to do things right.

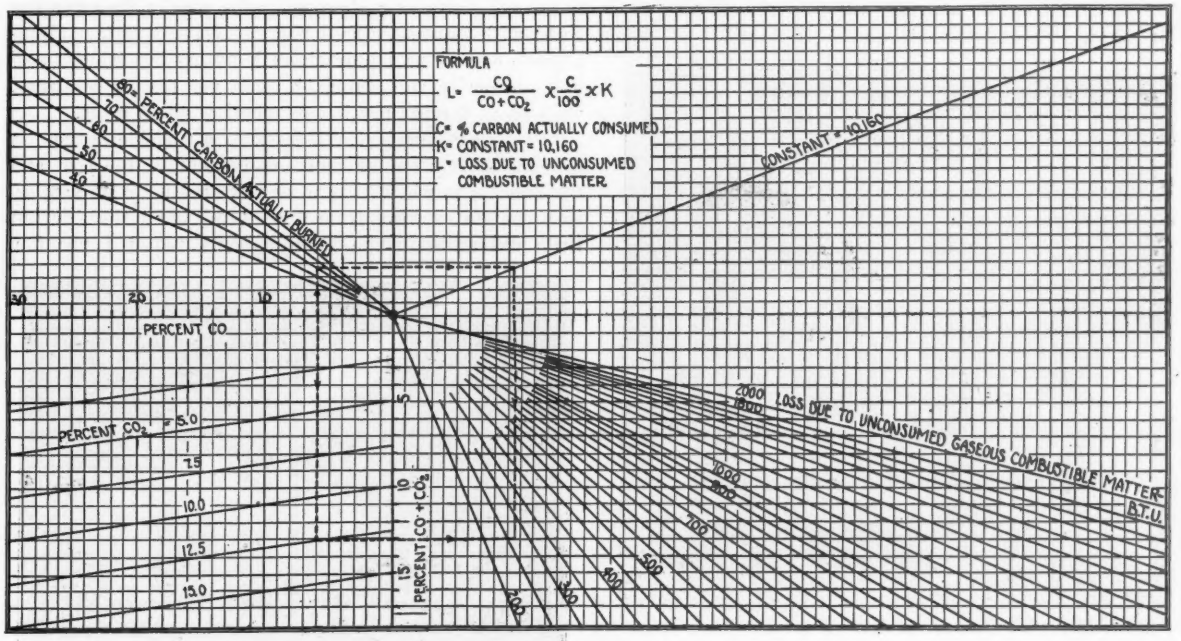


FIG. 9. CHART FOR DETERMINATION OF THE LOSS IN B.T.U. DUE TO UNCONSUMED GASEOUS COMBUSTIBLE MATTER

Enter chart on line showing per cent CO, read up to per cent carbon burned, then horizontally to the line marked constant and then drop a line straight down into the lower right-hand quadrant. Beginning again with the CO drop down to the per cent CO_2, then extend a line horizontally into the lower right-hand quadrant to intersect with the line previously drawn. This intersection shows the loss in B.t.u.

Unconsumed gaseous combustible is a function of the analysis of the flue gas and the net carbon consumed. A higher CO_2 will cut down on this loss. The radiation and the unaccounted for loss in our problem is not excessive. In actual operation it would be well, however, to inspect and place in first class condition the furnace and boiler setting insulation as well as that over the steam drums and drum heads. Taken as a whole, our problem would indicate that an efficiency of probably not less than 75 per cent could be obtained.

Over a long period of operation there are certain losses which cannot be entirely prevented but they often open the way to a great loss of fuel. These losses may be stated as: (1) Heat loss in shutting down boilers. (2) Coal required to start up a cold boiler. (3) Coal used in banking fires. (4) Heat lost in blowing down the boilers and in using soot blowers and the steam lance. Over a long period of time these losses may range from 5 to 15 per cent or more of the total heat generated.

To cut down these losses it is necessary to have only such boilers fired as are actually necessary to handle the load. It is an all too common error to have boilers loafing along which should not even be lighted.

Careful study of the coal used in lighting up and in banking fires will almost invariably result in savings. The

Provide Movable Centers for Chain Drives

FOR CHAIN drives always use an odd number of teeth in both sprockets when possible. Chains are regularly furnished with an even number of pitches and the combination of odd teeth and even pitches increases the life of the drive. Provide adjustment of distance between shaft centers wherever possible. Motors on rails cost but little extra and the additional cost is soon saved in easy adjustment of slack in the chain. Avoid vertical drives if possible but where vertical drives are unavoidable, center adjustment must be provided.

Where extremely quiet drives are necessary, such as ventilating fans in schools, halls, etc., a small pitch, wider chain, more teeth in pinion and slower chain speed are desirable. Drives which are to be subjected to sudden shocks or pulsating loads should be designed at least 50 per cent heavier than normal drives, according to the recommended practices of the Ramsey Chain Co., Inc.

NO ONE need ever be afraid for the truth. The truth is going to survive.

Powdered Coal for Small Boiler Plants*---II

UNIT PULVERIZING SYSTEM IS READILY ADAPTABLE TO SMALL BOILER INSTALLATIONS. BY T. W. ATTERBURY

WHERE PULVERIZED coal is already being used in a plant for metallurgical or other purposes, small boilers can be satisfactorily and economically changed from hand or stoker firing to pulverized coal firing by simply connecting in with the existing central preparation plant. The additional equipment required consists

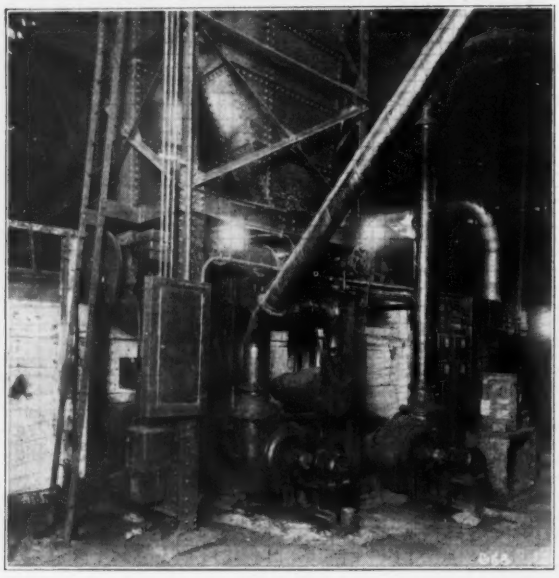


FIG. 1. BUT LITTLE ADDITIONAL EQUIPMENT IS REQUIRED WHERE PULVERIZED COAL IS ALREADY IN USE IN THE PLANT

of a storage bin, a coal feeder from the bin, a blower to receive coal from the feeder and convey it to the burners, a secondary air blower to furnish air for combustion, a set of burners, and of course, the necessary changes in the design of the boiler setting. An arrangement of this character is shown in Fig. 1. In Fig. 2 is shown an arrangement of coal and air lines from the coal blower leading to the burners at the top of the combustion chamber.

As each boiler is a self contained unit, it may be equipped and operated entirely independent of any other boiler. The pulverized coal is circulated to each of the boiler hoppers through a 4-in. pipe line by means of a pneumatic conveyor system. The air required for this purpose amounts to approximately 350 cu. ft. per ton of coal handled where the air pressure is about 25 lb.

Any boiler can readily be cut in or out of service by means of switching valves on the coal line and gate valves on the steam line.

To determine whether a unit pulverizer or a central station system will be best suited for any particular installation, a careful study of local conditions and boiler capacity must be made. First cost should not be considered of prime importance. Repairs, maintenance, power consumption per ton of coal pulverized, reliability of the equipment and flexibility of the feeders should all be carefully considered and a comparison made on the basis of this consideration.

Generally speaking, the unit pulverizer system is likely to be shut down more frequently for repairs than the low speed mills ordinarily used with the central plant. Maintenance cost of unit pulverizers handling bituminous coal will ordinarily run about 12 cents per ton as compared with about 6 cents per ton for the low speed mills.

Power consumption is necessarily a variable figure. It depends largely on the moisture content of the coal and the fineness to which it is to be pulverized. With a moisture content varying from 1 to 4 per cent, there is but little difference in the kilowatt-hours required per ton.

FIG. 2. ARRANGEMENT OF COAL AND AIR LINES FOR FEEDING INTO THE TOP OF THE COMBUSTION CHAMBER

With the moisture content varying from 4 to 7 per cent, the power requirements per ton will be increased from 1 to 1.5 kw-hr.

With the free moisture content varying from 1 to 3 per cent, the mill capacity is not materially changed, but where this content is increased from 3 to 7 per cent, the mill capacity may be decreased as much as 10 or 15 per cent. Under normal conditions the unit pulverizer requires approximately 21 kw-hr. per ton pulverized, whereas the slow speed central preparation plant requires but from 12 to 14 kw-hr. per ton with the moisture content not exceeding 6 per cent and the fineness approximately 75 per cent through a 200 mesh screen.

Pulverized coal equipment may be advantageously installed on waste heat boilers for use when the normal heat supply is cut off. With such a system the boiler may be started up quickly and the coal feed may be cut off instantaneously when desired. Coal may also be used to supplement the waste heat supply in case there is a shortage from that source.

In Fig. 3 is shown an outline of a successful waste heat boiler installation fired with pulverized coal. In this

*This is the second of a series of three articles on this subject. The first appeared on page 937 of the September 15 issue and the third and last will appear in the Octobr 15 issue.

plant the pulverized coal is used principally for firing reverberatory furnaces and the coal is supplied from a central station. Under these conditions a unit type pulverizer could readily be installed in connection with the waste heat boiler as an alternative or as a supplement to the waste heat supply.

In general, vertical boilers are so designed that the burners feed into the combustion chamber vertically, the path of the flame being downwards for some distance and then doubling back on itself and rising vertically to the first boiler pass. Such a design is illustrated in Fig. 4.

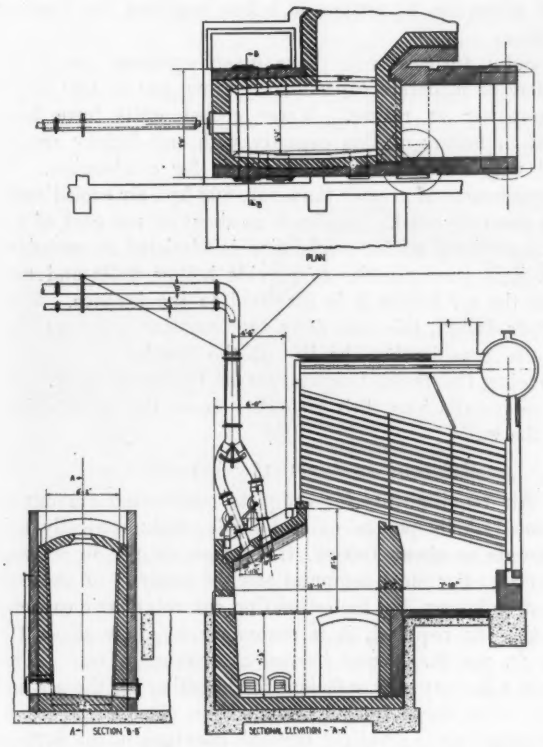


FIG. 3. PULVERIZED COAL EQUIPMENT IS ADVANTAGEOUSLY APPLIED TO WASTE HEAT BOILERS

Horizontal boilers may be fired either with vertical or with horizontal burners such as shown in Fig. 5.

Proportions of Combustion Chambers Are Important

Obviously, the proportions of the combustion chamber have a considerable bearing on the method of firing. The total cubical content of the combustion chamber, the depth and cross sectional area, have each to be considered carefully.

If the ash is to be disposed of in a light, easily removed, dry, friable or powdery form, the volume of the combustion chamber must be large. If, on the other hand, the ash is to be disposed of by melting and running off in a fused condition, the combustion space may be considerably less. When light ash removal is desired, as is the general practice, a furnace volume of approximately 5.5 cu. ft. per boiler horsepower at rating gives good operating results in as far as brick work maintenance and ash removal is concerned. Another method for determining furnace volume is to allow 45 cu. ft. per lb. of coal burned per min. at maximum rating. A more accurate method

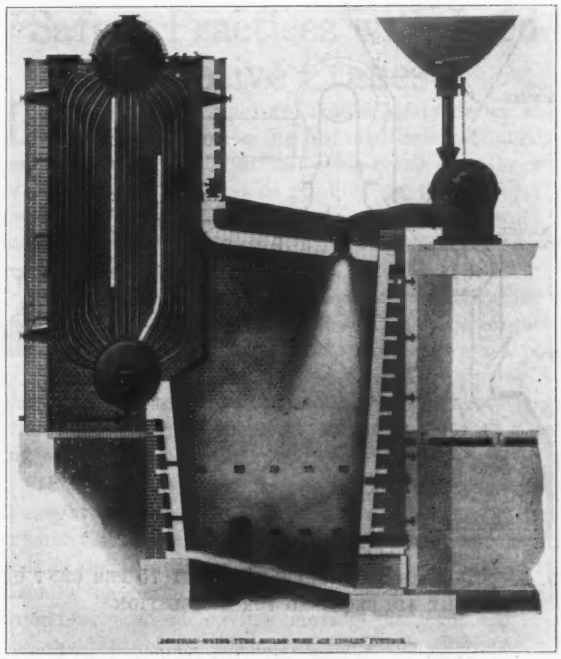


FIG. 4. PATH OF THE FLAME IS FIRST DOWNWARDS AND THEN BACK UP AGAIN

is to determine the heating value of the coal and to allow about 12,600 B.t.u. to be generated per hour per cu. ft. of combustion space. Combustion chamber volumes have been determined largely by experiment and by profiting by the mistakes made on some of the earlier installations.

Cost of the combustion chamber will vary with the volumetric capacity and some designers go to the extreme in order to insure a satisfactory ash disposal. The depth of the chamber must be such that with the longest flame encountered, the temperature will not be high enough to fuse the ash. In other words, the temperature of the bottom of the combustion chamber must always be lower than the fusing point of the ash if the ash is to be removed in a light, loose form. Where ash is to be removed in the liquid form, the depth and consequently the cost of the combustion chamber may be considerably reduced. This

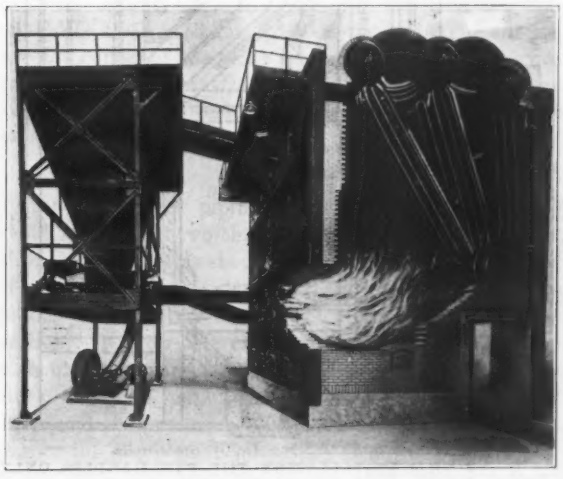


FIG. 5. APPLICATION OF HORIZONTAL BURNERS

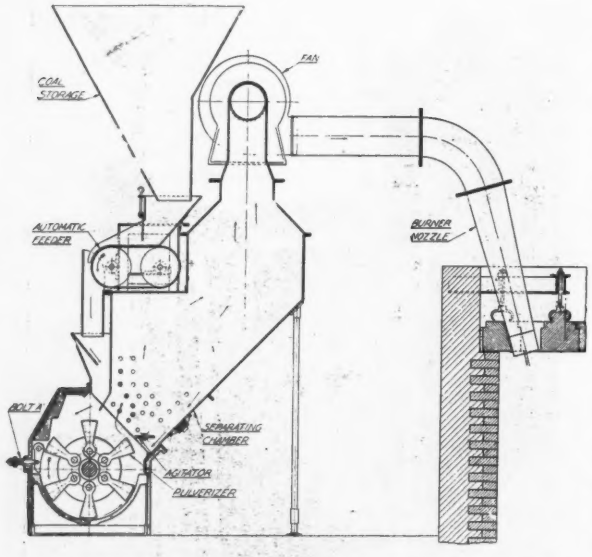


FIG. 6. SECONDARY FAN SUPPLIES ABOUT 75 PER CENT OF THE AIR REQUIRED FOR COMBUSTION

is an important consideration in changing over old boilers to pulverized coal as frequently it is not possible to get the necessary depth for fine ash removal. Some manufacturers have developed and others are experimenting with ash removal in liquid form. As this method is being successfully used on industrial furnaces important developments along this line can reasonably be expected.

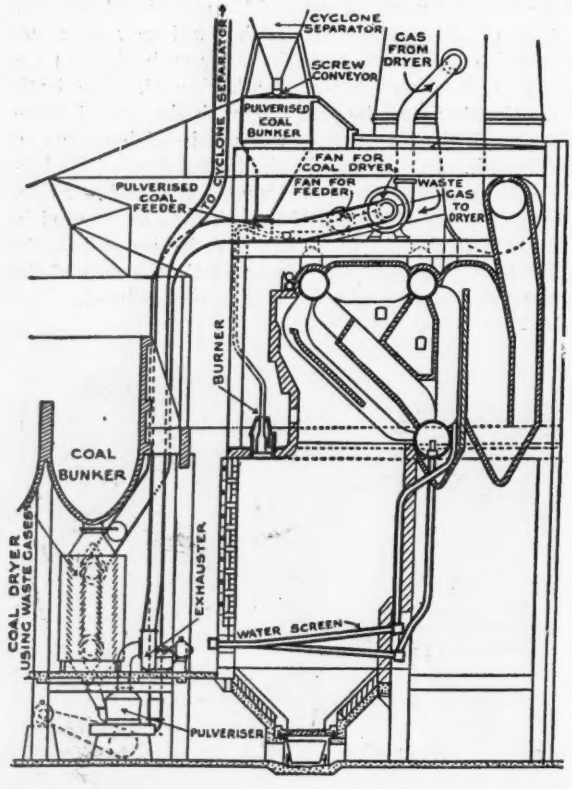


FIG. 7. IN THIS INSTALLATION THE FAN HANDLES ONLY ENOUGH AIR TO CONVEY THE COAL

Obviously, the cross-sectional area of the combustion chamber has an important relation to the velocity of the furnace gases. Too high a velocity has a scouring action on the brick work and causes a tendency to bypass some of the boiler tubes. Experiment has shown a good velocity of gases through the combustion chamber to be about 5 to 6 ft. per sec. Velocities greatly in excess of these figures will carry burning particles of coal through the combustion chamber and into contact with the rear wall or with the boiler tubes. Ash will also be carried along in a plastic state and will adhere to any surface with which it may come in contact. Conversely a low gas velocity will allow ash to settle out before reaching the heating surface.

Solid furnace walls have given excellent results in boilers of moderate capacity, say from 400 to 600 boiler horsepower at rating. Water cooled walls have been used in boilers of this capacity with satisfactory results and with a minimum of excess air for combustion. In larger boilers of greater than, say, 800 hp., air cooled walls are generally used. Inasmuch as about 75 per cent of the total air required for combustion is admitted as secondary air, it is good practice to provide hollow walls and preheat the air before it is admitted to the furnace. With proper design, this cuts down the radiation losses and increases considerably the life of the fire brick lining by reducing the mean temperature of the brick work. On large installations, this also cuts down the total weight of the walls.

Methods of Supplying Air and Coal

Air requirements for complete combustion amount to about 11.5 lb. per lb. of coal fired. Volumetrically this amounts to about 150 cu. ft. of free air per lb. of coal burned. For close computations the analysis of the coal must be known, but for estimating the volumetric capacity of the fan required, it is customary to allow about 180 cu. ft. per lb. of coal burned at maximum rate. This gives a fan capacity sufficient for handling all the air and coal to be blown into the combustion chamber where no secondary air is admitted through openings in the furnace walls.

Some types of unit pulverizers draw in air to propel the coal through the pulverizer in sufficient volume to furnish the 150 to 180 cu. ft. required for complete combustion. The air volume can be properly regulated and by the aid of a CO_2 recorder, the correct proportion of air may be admitted so that 16 to 17 per cent CO_2 may be attained without any CO. When firing with equipment such as shown in Fig. 3, all of the air for combustion is introduced through the burners where it is intimately mixed with the coal. This method of feeding is frequently used when burning coal furnished by a central preparation plant to a bin near the boiler. Other makes of unit pulverizers draw into the machine just sufficient air to carry off the fine coal in suspension, leaving the coarser particles for further grinding. The rest of the air required for combustion is furnished by a secondary fan having a regulated inlet, the fan discharging all the air and coal through mixers and burners into the combustion chamber. Figure 6 shows such a system.

In large boiler plants where the coal is prepared in a central pulverizer installation and blown to a bin at the boiler, air can be admitted to the combustion chamber in either one of two ways. In one method, a fan furnishes

about 15 per cent of the total air required for combustion. This 15 per cent carries in all the coal through the burners at a pressure of about 3 oz. at the mouth of the burner. Around the outside of the burner about 10 per cent of the total air is induced to keep the burner casting cool and to support ignition. The balance of the air for combustion, 75 per cent, is drawn through the hollow furnace walls by furnace draft and into the furnace in such a way as to effect good mixing with the coal. Such a system is illustrated in Fig. 7.

Another method of air supply used with central preparation plant equipment is as shown in Fig. 1. Here the coal is fed by a special screw feeder from the bin to the coal blower. This blower delivers the coal, with a minimum amount of air to clear the pipe, into the so-called volume air supplied by a secondary air blower. The air and coal mixture is then thoroughly intermingled and blown through the burners into the combustion chamber

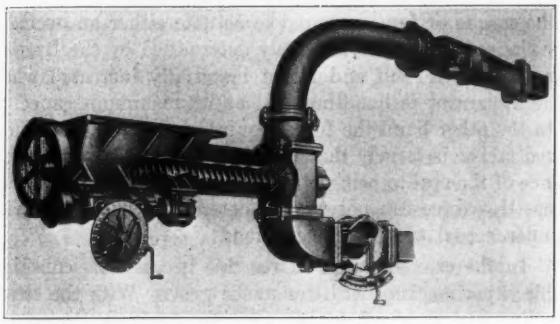


FIG. 8. THE DISCHARGE END OF THE SCREW CONVEYOR SHOULD BE LARGER THAN THE INLET END TO PREVENT PACKING

at a pressure of about ½ oz. In this method of firing, all the air for combustion passes through the burners with the coal, some of the secondary air being preheated by circulating through the hollow furnace walls.

With the unit pulverizer, no special coal feeder is required. Pulverized coal is drawn from the mill and is blown, with the proper amount of air, direct to the combustion chamber. When the pulverized coal is drawn from a bin located near the boilers a specially designed screw is used as shown in Fig. 8.

For the best firing conditions, the rate of coal feed should be uniform, the discharge end of the screw should be of larger capacity than the inlet end so that the coal loosens up and discharges freely. An equalizer disk is shown on the discharge end which mixes the coal with the air current and gives a mixture of coal and air of uniform composition. The screw should be able to deliver dry coal and moist coal equally well; that is, coal containing from 1 to 5 per cent free moisture. If, for any reason, coal having a higher moisture content than 5 per cent is used, some difficulty may be experienced in obtaining uniform coal feed. One of the principal reasons for drying coal in the large plants is to eliminate conveyor and feeder troubles encountered with moist pulverized coal.

AFTER taking up any bearing, watch it carefully for awhile so as to be sure it is not too tight. If it shows any signs of heating, ease up on it and gradually tighten it up as it comes down to a bearing.

Safety Practices with Locomotive Cranes

LOCOMOTIVE cranes are both a safety device and a hazard, according to the National Safety Council, in one of its recent publications. One crane does the work of 50 men—48 men less to get hurt on the job—yet its use has been the cause of numerous fatalities which in most cases have been the result of violation of well-known safety rules.

Accidents sometimes occur through material falling on men standing under the load. When an electric magnet is used for handling iron and steel there is always a possibility of the current failing and the load dropping and clam shell buckets used in handling ore, limestone and other loose materials, frequently drop large pieces. Standing within swing of the boom is also hazardous.

Most of the fatalities, however, occur when the victim is caught between the cab and the truck platform when the superstructure swings around. When this happens, the body of the unfortunate man is likely to be sheared in two. Usually the victim is at fault for placing himself in this dangerous position. When moving the load, the crane operator can not see the part of the crane where the danger lies and does not know anything is wrong until the accident happens.

Recently a device known as a "deck swipe" has been developed by the Oliver Iron Mining Co., Ironwood, Mich., to eliminate the shearing action when the superstructure swings around. The deck swipe consists of a piece of steel plate reinforced with an angle iron and with a piece of steel pipe welded on the edge to give it a rounded effect. There is no shear point as the crane swings around and a man standing on a sill step or on the ground beside the truck would be pushed out of the way and serious injury avoided. The hole in the middle of the deck swipe serves as a step when the crane is in the traveling position.

No mechanical substitute exists for education and discipline of employes entrusted with the operation of cranes. Members of the National Safety Council have placed special emphasis on this factor in locomotive crane safety. Making it difficult to ride or climb on the crane frame by removing all grab irons and sill steps is a simple but effective safety measure employed by several members of the National Safety Council. The only steps on the crane should be those used for access to the cab. The sill steps at each corner of the truck are only an invitation for the men to catch a ride. Outriggers and track clamps to prevent cranes from overturning are invariably endorsed by safety engineers.

IN LAYING OUT piping, every care should be taken to avoid air pockets, which are a common source of annoyance. A suction line should gradually rise from the source of supply to the pump, so that there will be no part of the piping in which air can collect. An air pocket in the suction line invariably causes the pump to lose its water without any apparent reason. When the pump is originally primed, the suction line may be completely filled with water and thus no air pocket exists but during the operation of the pump small quantities of air will separate out of the water and gradually collect until the air pocket is filled, which will cause the pump to lose its water.

The Steam Engine as a Stoker Drive

Slow Speed, Continuous Range and Automatic Torque-Speed Adjustment Are Among the Desirable Characteristics

OF ALL the auxiliaries required in the modern power plant, probably that used for driving stokers is subjected to the hardest service and has to meet the most exacting requirements. In general, two methods of drive may be employed; prime movers and secondary sources of power. Where a prime mover is to be used, the simple steam engine has been found eminently satisfactory and is used in the great majority of plants.

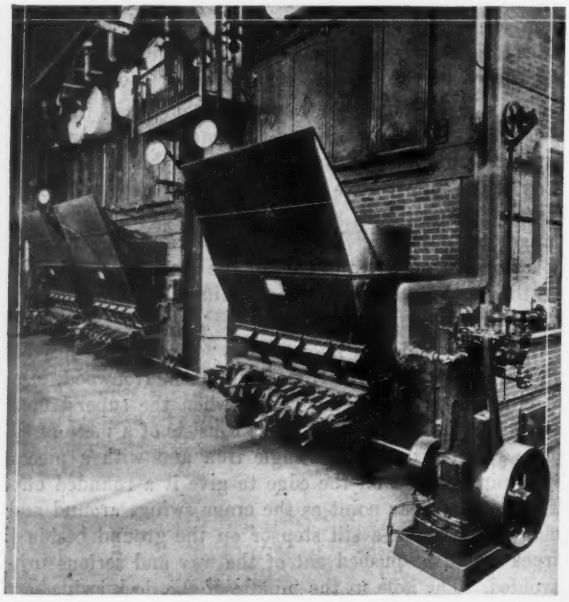


FIG. 1. TOTALLY ENCLOSED ENGINE AFFORDS PROTECTION FROM DUST AND DIRT IN THE BOILER ROOM

Among the principal desirable characteristics of any stoker drive are wide and continuous speed range, power flexibility, durability, adaptability to various forms of stoker connections and methods of speed control, low installation, maintenance and operating costs and small space requirements.

Speed and Power Flexibility Are Desirable

Except on boiler and stoker combinations, carrying constant base loads, there is a continual fluctuation in the demand for steam. To maintain a constant pressure and to avoid unnecessary popping of the safety valve the rate of firing should correspond closely with the steam flow. If, then, the highest possible over-all efficiency is to be obtained, the stoker speed should be variable and the range should be continuous from the minimum to the maximum.

With selective gears and a constant speed drive a number of definite speeds may be obtained and the range may be more or less continuous, if the drive has a certain speed flexibility. If special variable speed transmission devices are employed, a continuous range of speed may be obtained with a constant speed drive. These various combinations find a wide application in many kinds of service but they introduce, nevertheless, certain complications.

Where a steam engine drive is employed, a continuous speed range is available as this is one of the inherent characteristics of this type of prime mover. With the right kind of throttle control, the steam engine is capable of handling a constant torque at any speed or over any range of speeds up to the maximum and of automatically adjusting itself to unusual conditions or to unexpected peak loads.

Unlike almost every other power plant auxiliary, except perhaps coal and ash conveyors, the power requirements for a contemplated stoker installation cannot be accurately foretold for various conditions of operation. The matter of proportioning the engine capacity is then largely one of experience and is not subject to mathematical precision. The torque or force required to actuate either an overfeed or chain grate stoker is largely determined by the friction in the stoker itself and is not materially increased when the apparatus is handling coal at its maximum capacity. On the other hand the force required to operate an underfeed stoker is largely that required to overcome the resistance of the coal to being pushed into the retorts. In either case this force can not well be determined except by trial under actual operating conditions.

In the case of motor drives this necessitates considerable experimenting with resistance grids. With the steam engine any required torque may be obtained, up to the maximum. It is essential, of course, to select an engine

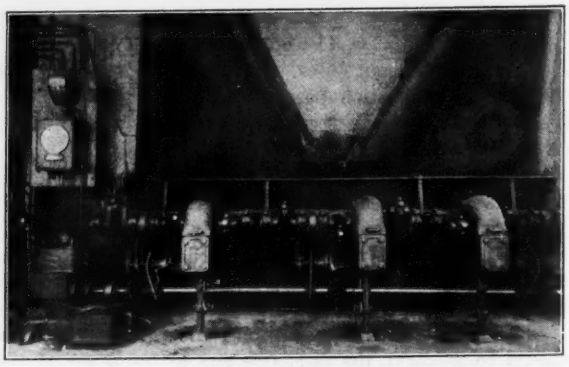


FIG. 2. TRUNK TYPE ENGINE APPLIED TO AN UNDERFEED STOKER

that will be able to develop the maximum torque necessary and this is a matter for the judgment and experience of the designer. As a matter of fact the engine selected is usually considerably oversized to insure ample torque with low boiler pressure.

Properly Designed Engine Has a Long Life

Obviously, durability is a desirable characteristic of any piece of power plant equipment but it becomes of much greater importance where the apparatus is subjected to hard wear and is of particular significance in stoker drives. The stoker engine, exposed as it is to the usual dust and dirt in the boiler room, must be built to withstand these conditions and to hold up in this trying environment. To

this end all wearing parts should be amply proportioned, well protected and well lubricated. Bearing pressures must be kept at a minimum consistent with a reasonable first cost. Further, the engine should be as simple and as elementary as possible. All unnecessary auxiliaries should be eliminated. Every accessory simply adds to the liability of failure, consequently their use should be limited. While these auxiliaries may, in the case of the ordinary engine, add to the efficiency, they defeat their purpose when applied to stoker engines. Most engines built for stoker drive are, for this reason stripped down to the fundamental elements.

Ample protection is probably the best insurance against rapid wear and short life. Other factors being equal, the engine which has entirely enclosed bearings, crank, connecting rod, piston rod and valve mechanism is best suited for use in any boiler room, even the cleanest.

Low Speed Simplifies Gearing

Stokers are, of necessity, extremely slow moving pieces of equipment and, except in the case of certain types of underfeeds operated periodically by a direct ram, require the use of some kind of speed reducing gearing between the direct shaft and the prime movers. Of the several types of motive power available, the steam engine has the lowest speed compatible with good economy and, therefore, requires the least speed reduction, only a spur gear combination or single worm gear. The maximum speed of a chain grate stoker, for instance is of the order of 3 to 12 in. per min. corresponding to from about $\frac{1}{16}$ to $\frac{1}{8}$ r.p.m. of the sprocket shaft. To reduce to this speed from the ordinary maximum speed of the engine, requires only a simple chain of spur gears.

Engine Is Readily Adaptable to Various Forms of Control

To obtain the utmost in overall boiler, furnace and grate efficiency, it is essential that the stoker speed be closely correlated with the load. This is done by means of some form of control actuated either by steam pressure, steam flow or furnace draft. Opinions differ as to which is best adapted for the purpose but the point is that some form of automatic control is highly desirable. In order that a control be effective, it is, of course, necessary that the motive power driving the stoker be readily susceptible to the influence which the control may exert. In the case of the steam engine drive this speed control may readily be obtained by the use of a simple throttling governor actuated by any of the several means mentioned.

Costs Are Comparatively Low

Installation cost of a steam engine drive is relatively low, owing to the comparative simplicity of the construction and the lack of necessity for large speed reductions. As to maintenance and operating costs much depends on the personnel of the operating staff. Slovenly methods and lack of interest on the part of the crew will mean high costs no matter what the design may be. Other things being equal, however, the sturdy, well inclosed engine will require but little maintenance.

The ability to anticipate trouble is an item of considerable importance in keeping down maintenance costs. This means of course frequent inspections and familiarity with the apparatus. With the steam engine abnormal operation, knocks and unusual noises are comparatively easy to detect and prolonged and costly shut-downs may be avoided if prompt attention is given to every indication of faulty operation.

Operating costs will embrace such items as steam consumption, lubrication and attendance. Steam consumption of the engine under various conditions of operation may, obviously, whatever the steam consumption of a new unit, increase with time and wear, the rate of increase depending on the care exercised in operation and maintenance and the design and construction of the unit. The steam engine will however, give a satisfactory performance in this respect.

Adequate lubrication is of prime importance in prolonging the life and maintaining the operating efficiency of any piece of machinery. Money effectively spent on this item will be well repaid in increased operating economy and reduced maintenance and depreciation costs. If the correct grade of lubricant for the purpose is used and if it is properly applied, appreciable savings may be effected.

FIG. 3. DIRECT-ACTING PLUNGERS FOR UNDERFEED SERVICE

Ordinarily the question of attendance is given a place of secondary importance in the installation of stoker drives, hence the necessity for rugged construction and adequate protection from dust and dirt. Were the usual attendance of a higher order more delicate and more efficient drives might well be used. Being what it is and not easily susceptible to change, the better engines for this purpose are usually so constructed as to be as little influenced as possible by the human element in operation.

Usually space is at a premium in the boiler room, consequently it is desirable that the space requirements of all auxiliary apparatus, including the stoker drive, be as small as possible. Owing to the absence of a long train of reducing gears necessary with high speed drives the steam engine, especially the vertical type most frequently used, is ideal in this respect. Even when located on the boiler room floor immediately adjacent to the stoker, it will not ordinarily be in the way but, if this space is needed for some other purpose, the engine may readily be mounted either in the basement under the stoker or on a platform above the operating level and the stoker may be driven by means of a belt or a chain and sprocket arrangement.

In determining the engine capacity that should be used on any given stoker installation, the most important factors that must be taken into consideration are the type of

stoker used, the grate area and the rate of travel. As has been said it is a rather difficult matter to predict the power requirements of an installation with any degree of accuracy but there are certain average values available which may serve as a basis for an estimate.

Ordinarily the power requirements for underfeed stokers will amount to from 0.3 to 0.5 hp. per retort, depending, of course, on the size of the retort, the kind of coal to be used, and the number of strokes per minute. Multiple retort stokers are fitted with engines up to 15 and 20 hp. depending on the number and length of retorts and the overload capacity desired.

Chain grate stokers ordinarily require from 2 to 10 hp. engine capacity. Usually, however, owing to the necessity of operating at times with low steam pressure, engines of capacity greater than that normally required are used. One boiler manufacturer makes it a practice to install engines that will develop approximately 1.6 hp. for every 100 sq. ft. of aggregate grate surface served.

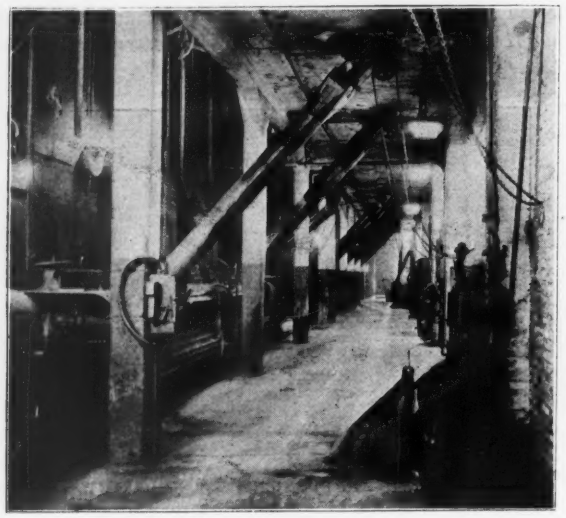


FIG. 4. VERTICAL ENGINES DRIVE CHAIN GRATE STOKERS THROUGH LINE SHAFTING UNDER THE FLOOR

Ordinarily the limits of engine capacity are governed by the general design of the boiler room although it is usually customary to serve not more than from 800 to 1000 sq. ft. of stoker grate surface from any one engine. In other words, a 16-hp. engine is about the maximum size that is ordinarily used for this service.

In what might be called a typical or representative installation, one 5 by 6-in. engine operating on 150 lb. boiler pressure drives, through a line shaft under the boiler room floor, the chain grate stokers on three 520-hp. and one 250-hp. boilers operated at rating. This arrangement is capable of handling considerable overload and at the point where the engine is developing its rated capacity the output amounts to from 0.25 to 0.30 of 1 per cent of the boiler capacity. Steam consumption may amount to approximately 0.60 of 1 per cent of the total generated but for the best engines may be as low as 0.45 of 1 per cent of the total generated.

While it is true that by far the greater number of stoker engines operate on saturated steam, they have been used successfully with superheated steam at pressures up to as high as 250 lb. As long as the total temperature is not excessive, little difficulty is to be expected and such engines have been operated successfully on total steam temperatures as high as 600 deg. F.

In the smaller industrial and central station plants having the boiler capacity divided into comparatively small units, it will be found common practice to have one engine drive a number of stokers by means of a line shaft. Where the arrangement is such that any stoker may be driven from any engine, greater economy and greater reliability result. Where the individual boiler units are of such size that it is more economical to use an engine for each stoker there is some sacrifice of reliability, unless each unit is provided with a standby source of power or the plant is equipped with an extra engine that can be connected up to any stoker in case of an emergency. In one industrial plant now under construction, where each stoker has a separate engine, the management has provided an extra unit, mounted on a truck which can be connected up through flexible steam couplings to the steam supply and by means of a belt to the stoker shaft on extremely short notice. By this means the boiler unit can carry over the peak load until such time as it can be taken off the line for repairs.

Removing Cast Iron Pulleys by Breaking

By W. F. SCHAPHORST

IN CONVERSATION with a master mechanic not long ago regarding power transmission matters, I was interested in hearing him say that he has often found it cheaper to break off a cast-iron pulley when removing it than to go to the expense and trouble of removing the shaft and a number of other pulleys and possibly find it necessary to remove one of the hangers themselves in order to get the pulley off.

He said that he finds no difficulty in breaking off the rim and the arms, but he sometimes has a little trouble in breaking the hub; two men, however, can usually do the work in a short time. One of the men holds an anvil against the pulley at the top, while the other man does the striking from the bottom. In that way there is no danger of springing or otherwise harming the shaft and it is easier to apply considerable pressure against the shaft by means of the anvil from the top than from the bottom.

ALL THE stuffing-boxes subject to a vacuum on centrifugal pumps should be piped up for water seal to prevent air from leaking into the pump. This applies to both stuffing-boxes on double suction pumps and also on multi-stage pumps equipped with balancing pipe between suction and discharge side. On multi-stage pumps, without a balancing pipe, it is only necessary to water seal the suction stuffing-box. The water used for sealing should be clear, free from grit and sand, and if the pump is handling clear water, the connection to the stuffing-boxes may be made from the volute of a double suction pump or from the first stage of a multi-stage pump. If the pressure is high, a valve should be placed in the pipe connection to throttle down the pressure. Stuffing-boxes under pressure do not require any water seal.

Use of Diesel Engines in Power Plants

CONSIDERATIONS AFFECTING THE ADAPTABILITY OF THE DIESEL ENGINE.
PRESENTED BEFORE THE N. A. S. E. CONVENTION BY LOUIS R. FORD*

AS COMPARED with the steam engine the Diesel engine is actually more simple. It appears more complicated because all of the accessory equipment needed for its operation is included in the engine structure. If all of the equipment required to operate the steam engine, including boilers, condensers, feed pumps, heaters, air pumps, feed tanks, separators, gages, steam traps, superheaters, etc. were included in the engine structure it would make a weird and complicated appearance beside which the Diesel engine would be the acme of severe simplicity.

One important difference in the operating characteristics of the Diesel engine and the steam engine is that the steam engine economy is greatest in the large units and as the size decreases the pounds of fuel consumed per horsepower increases, while the economy of the Diesel engine is constant over practically the whole range of sizes, the small engine being practically as economical as the large one. Considering the economic results obtained from large steam turbine units and the comparatively small power it is now possible to produce in a single Diesel engine unit, it is evident that for use in great central power stations that serve the more densely populated sections the Diesel engine is not competitive with the steam turbine. These huge plants with single units of 30,000 kw. or more capacity are impressive because of their size but their relative importance is revealed by an analysis of the power situation throughout the U. S.

Recently a survey of the power field showed that the total stationary power generated in this country is over 50,000,000 hp. of which 61 per cent is produced in steam engines, 25 per cent from water power and 14 per cent in internal combustion engines. This comparatively small per cent of internal combustion engine power is rapidly increasing, due to several factors, among which are the increasing reliability and simplicity of the engines and the availability of fuel oil. The predominant factor in the petroleum industry is the production of gasoline for use in automobiles and as long as the huge demand for gasoline exists there will be plenty of fuel oil available, because with every gallon of gasoline that is produced we get 2 gal. of fuel oil.

If we analyze this power situation we find that, leaving out the comparatively few large central power plants, the vast bulk of our 50,000,000 hp. is produced in plants that average 100 hp. and throughout the country the generation of power for manufacturing plants by the plants themselves is a problem of small power plants. It is the big plant that gets the publicity but it is the small plant that supports American industry.

DIESEL IS MOST COMPETITIVE IN SMALL PLANTS

It is in these small plants that the Diesel engine is most competitive because no amount of heat saving devices added to the small steam engine will make it as economical as the Diesel. This increase in superiority of the Diesel over the steam engine as the size of plant gets smaller is the reason why, for every power plant in existence, there is some definite size below which it is more economical to use Diesel engines and above which it is more economical to use steam. This size is, however, by no means the same for every plant. It may vary over as wide a range as 20 hp. to 5000 hp., depending on various factors, such as location, cost of fuel in that locality, necessity for process steam in manufacturing and various other circumstances that may affect the operation of any one particular plant. The only way, then, to determine where the dividing line between steam and Diesel power lies is to analyze each separate plant and the conditions under which it operates.

For any one power rating the costs of the steam plant and Diesel plant should be tabulated, including purchase price of all machinery, cost of buildings, cost of installation, insurance and depreciation. This will determine the fixed charges. In fixing a figure for depreciation the mistake of assuming shorter useful life for the Diesel engine than for the steam should not be made. Diesel engines have not been in general use long enough to establish just what the life of such an engine will be but it is pretty definitely established that it will not be shorter lived than the steam engine.

In most cases it will be found that the Diesel engine costs more than the steam plant and its fixed charges will be higher. Operating costs will be determined by tabulation of wages, cost of repairs, cost of lubricating oil and fuel. Such analysis, reduced to terms of cost per year per horsepower produced will show in each case that there is some size below which the balance is in favor of the Diesel and above which it is in favor of the steam plant.

In most cases it will be found that the cost of fuel in the particular locality under consideration will be the controlling factor. This analysis will also bring out the interesting fact that in many cases where the Diesel fuel is much higher in price than boiler fuel the use of the Diesel engine will still show a saving because of its much greater efficiency.

History of Diesel engine operation is full of tales of harrowing experiences that have fallen to the lot of engineers who "tried to make the thing run." These experiences have arisen from various causes, among which are the engines themselves, peculiar local conditions or circumstances and, sometimes, unfamiliarity of the engineers with the engines.

Any gathering of engineers will bring forth a number of such narratives but it is equally true that nearly every engineer of long experience can talk interestingly of the "grief" he has had at times with steam machinery. In general, however, the record of operation of a Diesel engine plant is one of satisfactory service under conditions made more pleasant by the absence of many of the annoyances necessarily associated with the steam plant. The Diesel engine lends itself readily to the bettering of working conditions and the production of attractive appearance in the engine room.

Perhaps the most important single factor in successful Diesel engine operation is the establishment and maintenance of an operating routine. The ideal plant is one in

*Consulting Engineer

which there are enough units to keep one or more in reserve. This permits all routine repairs, examinations and cleaning to be made at fixed intervals, without the necessity for hurrying or leaving some of the work uncompleted in order to keep the engines running. Correct and efficient performance is quickly affected by the condition of the cylinder head valves and these should be examined at regular intervals. The exhaust valves have a severe duty to perform as they operate often at a red heat, must pass hot gases at high velocity and are subject to the cutting action of any gritty material that may be carried in the exhaust gas.

Fuel injection valves operate under less severe heat conditions but they are subjected to high air and oil pressure, must be perfectly tight and must open and close with accuracy and precision. The air intake valves operate under the least severe conditions. They are subjected to the heat and pressure in the working cylinders but on each suction stroke they are cooled by the inflowing cool, clean air.

It is the practice of some engine builders to make the intake and exhaust valves duplicates of each other. If it becomes necessary at any time to renew a valve it is always put in the inlet cage and the inlet valve moved to the exhaust cage. This permits gradual seasoning of a valve before it is used for exhaust and reduces the liability to warping. The plant routine should provide for removing all valves at regular intervals for examination, cleaning and any retouching that may be needed. If the plant demands are such that the engine cannot be shut down long enough to do this a complete set of spare valves should be carried. It requires only a short time then to shut down, remove the valves and install the spare set. The valves that have been removed can then be gone over carefully at leisure, put in good condition and put away for spares.

Measurements Should Be Made For Wear

At regular intervals the pistons should be drawn for examination of cylinders, pistons and rings. Measurements should be made for wear and an inspection should be made for signs of leakage past the rings. It is obvious that this examination need not be made every time the valves are overhauled. Experience is the best guide as to the frequency of such examinations but it is important that they be made according to a routine schedule.

Routine inspections should always include a careful check up on the interior of housings and crank cases for loose bolts and nuts; inspection of oil piping and water piping for leaks; repacking of valve stems where required; examination of air compressor pistons, cylinders and valves; and the examination of fuel measuring pumps and of bearings. It should be borne in mind that while a bearing that is too tight will quickly make its condition known a bearing that is loose may give no indication of this looseness, particularly when forced feed lubrication is used. If enough oil is fed into the bearings the pounding expected from a loose bearing will be prevented by the cushioning effect of the oil but there may be enough slack to reduce the compression in the cylinders.

Loss of compression from this or other possible causes cannot be definitely determined without the use of an indicator. The fact that many Diesel engines have run for years without having an indicator put on them does not make it any less true that the best operation cannot be expected unless the plant equipment includes at least one good indicator. The economy of the Diesel engine is directly affected by the compression and the valve timing. Any departure from the right adjustment can be determined only by taking indicator cards.

Many tests and experiments incident to the development of the Diesel engine have shown its ability to operate with an amazing variety of fuels, including the range of petroleum from kerosene to heaviest known crudes. An exploring expedition now in the Arctic is using an oil engine operating on whale oil, there are engines in China operating on palm oil and in Germany extensive use of tar oil is necessitated by the high price of petroleum. The use of these special oils involves special treatment or apparatus and is thus far confined to localities where the standard Diesel is not available. This standard oil is a petroleum distillate the gravity of which is somewhere in the range 24 to 30 deg. Bé. and is readily available throughout the U. S. With such oil the best operating condition, so far as the fuel is concerned, is obtained because no conditioning apparatus is required and no special precautions as to stopping and starting are involved. There is, however, a steadily increasing trend toward the use of boiler fuel oil in Diesel engines because of its lower price and world wide availability. This oil is of 12 to 16 deg. Bé. and requires some heating to reduce its viscosity enough to permit it to be readily handled by the fuel measuring pumps. In plants where steam is available this heating requirement presents no difficulty.

It is found, however, that the wear of cylinder liners and piston rings is more rapid with this oil because of its ash content. In the latest marine installations this trouble due to ash content has been reduced by passing the fuel oil, while hot, through centrifugal separators and thus removing most of the ash forming solids.

According to R. F. Jones, writing for the Leather Belting Exchange Foundation, belt creep, which, with true slip, makes up the total combined slip of a belt, is the direct result of the elasticity of the belting material. All materials have this property of elasticity, hence it is impossible to make a belt that will not creep. Although the use of special pulley coverings or belt dressing may increase the carrying capacity of a belt, it is impossible to eliminate creep by this means. Normally the loss due to creep will probably not exceed 15 per cent and this is offset by the effect of an elastic medium between the source of power and the point where it is used.

True slip, on the other hand, is not due to elastic action and is preventable by increasing the initial tension, or reducing the belt torque.

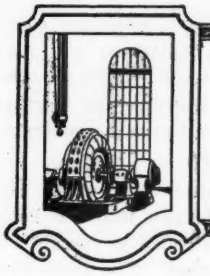
There were four states in the Union that registered in excess of one million automobiles during 1923.

Of the 1,093,660 autos registered in California, only 43,395 were commercial cars.

Of the 1,214,090 autos registered in New York, 247,974 were commercial cars.

Of the 1,072,750 autos registered in Ohio, 147,918 were commercial cars.

Of the 1,064,625 autos registered in Pennsylvania, 164,928 were commercial cars.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Examples of Power Factor Improvement

DESCRIBING THREE PRACTICAL WAYS OF STRENGTHENING POWER FACTOR IN INDUSTRIAL PLANTS. BY MORGAN G. FARRELL

SAY "power factor" to a layman and he will give you a blank stare. Try to explain it and his attention will wander out the window. If he happens to be a works manager he will try to understand what and why it is and how it can be regulated. His hard-working electrician has probably told him the same thing frequently, without creating much interest. The probable result of your explanation will be that he will take your word for it and tell you to "go ahead and fix it up."

It is safe to say that, in one out of every two motorized manufacturing plants, the power factor is far below good practice, and that nobody in the plant knows what it is in plain figures. Textile mills are special offenders in this regard, on account of the large percentage of individual-drive machines. These small motors have to be large enough to start, say, a 300-spindle frame under load. But the running power requirement is considerably less, fluctuating upward and downward as the spools are wound full and doffed to make way for empty ones. Induction motors running at less than full load tend to lower the power factor. Hence the cumulative effect of several hundred frame-motors running at half load will seriously affect the factor for the plant as a whole.

The same is true of planing-mills for example. A large planer whose maximum duty is to face four sides of a 2 by 12-in. hard pine plank at one operation, must be fitted with a 35 to 50-hp. motor. Under run-of-the mill conditions, it may be working on 1 by 8-in. boards or small timber or facing one side only, in which case the motor is running much below rating and the power factor is low.

Group-drive motors, as in machine shops are more likely to be run near capacity much of the time, since their size is determined by the average load percentage of the group of tools driven by them. Still other processes make a nearly even full-load demand upon the motors, as cement and chemical mills or continuous operations upon uniform material as box-board and paper mills. In such cases the power factor is likely to be reasonably high.

GRAPHIC DEFINITION OF POWER FACTOR

While many readers of Power Plant Engineering are thoroughly familiar with the causes and effects of low power factor it may not be amiss to recapitulate them briefly.

Figure 1 illustrates graphically what power factor is. In an alternating current circuit the current and voltage both pass from zero to positive maximum to zero to negative maximum and back to zero again—in each cycle. Sixty-cycle current means that this complete reversal takes place 60 times in a second.

The power or wattage is the product of the voltage and the component part of the current which is in phase with

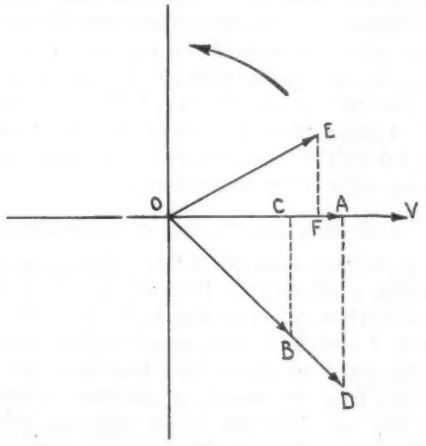


FIG. 1. EFFECT OF LAGGING CURRENT ON POWER FACTOR

it. If the load is a lighting circuit, that is one containing only resistance, the current and voltage are fully in phase. Maximum positive current and maximum positive voltage are simultaneous.

But if there is inductance (as an induction motor) in the circuit, its effect is to force the current to lag behind the voltage so that the volts pass through positive maximum before the amperes do, in each cycle. A condenser in the circuit has the opposite effect. It causes the current to lead the voltage.

Referring to Fig. 1, OV is the positive maximum voltage, say 220. OA is the positive maximum current, say 10 amp. The two are in phase as in a pure resistance circuit and the wattage is $220 \times 10 = 2200$. The direction of rotation being as indicated by the arrow, an inductive load would throw the current back of the voltage to the position OB. The component of OB effective for power is OC. That is the wattage is OC $\times$ OV. The other component, BC is called wattless current and is ineffective as power. If the inductive load is a motor requiring 2200 w. the power component of the current in phase with the voltage must be OA, 10 amp. To produce such a component,

the positive maximum current which is lagging behind the positive maximum voltage is lagging behind the positive maximum voltage by the angle AOB, must automatically become OD, which scales 14.1 amp. That is, the generator must develop 14.1 amp. and the conductors must be large enough to carry them, although only 10 amp. are effective as power.

The ratio of OA to OD is the power factor. In this instance it is 10 ÷ 14.1 or .7. The effect is apparent. If the generator is rated at 2200 w., it must be overloaded 41 per cent to produce that amount of effective power and the copper in the conductors to the motor must be increased. The General Electric Co's. tables illustrate the copper increase necessary by showing that for a load requiring 1134 lb. of copper at 1.00 power factor, the copper must be increased to 2320 lb. at .70 power factor. The fuses and switches in the circuit must be increased in the same ratio.

Now a condenser or synchronous motor (which acts like a condenser) in the circuit will cause the current to lead the voltage, say, by the angle AOE. If the condenser is alone in the circuit it will have the same net effect as the inductance, i. e., to reduce the power factor. If both condenser and inductance are in parallel in the same circuit they will offset each other; if they are equal the lead effect of one will balance the lag of the other; the current will be in phase with the voltage, and the power factor will be 1.00. This is the principle of power factor correction as in the following instances.

Increasing the Factor by a Condenser

As a flagrant example of low power factor, here is the case of a silk-mill in Philadelphia. The plant was partly electrified. Current was supplied to the induction motors by a 1000-kv.a. high pressure steam turbo-generator. The connected motor load was about 900 hp., the actual load from the recording watt-hour meter was 450 kw. or 600 hp. The rest of the mill was driven by a Corliss engine and line shafting.

During the construction of a new building in which all machines were to be electrified, it was decided to motorize fully the old plant. The power requirements were:

	Connected Load	Average Load
1. Old building (additional)...	720	480
2. New building	1100	800

Motors were installed in the old building and connected up to the generator bus-bars. They were tested at night and operated successfully. The next morning when the mill was in full swing, the new motors were started and promptly kicked out the main generator circuit-breaker. The trip was re-adjusted to carry more overload and the attempt repeated with the same result. Again the overload limit was increased and again the breaker failed to hold.

While the proposed load was being transferred back to the engine, an examination of the lines and connections was made by an electrical engineer who was hastily called. He reported all O. K. but announced that he wished to take some readings of current, voltage and wattage. His tests showed that the combined power factor of the plant as operated was .51.

At that power factor the 1000 kv.a. generator could deliver 510 kw. or 680 hp. approximately at full load capacity. The new running load was 600 + 480 = 1080 hp. a 60 per cent overload. And of course the starting load was much greater. At .80 power factor the generator could have carried the 1080 hp. easily.

Nothing was done about the situation at the time. The Corliss continued to function and the new mill was completed and equipped. It had been intended to operate the new building with public service current. The lines were accordingly brought in and all connections made. To all appearances the new mill was operating successfully.

The first month's bill changed the complexion of matters. There was an item of $450 penalty for failure to maintain a power factor of .85 as provided in the contract.

Again the engineer was called in to investigate and advise what should be done. He found that the power factor of the new mill was about the same as that of the old one. And he recommended that two synchronous condensers of proper capacity be installed in the engine room, one to be floated in the turbo-generator circuit and one in the public service.

His report was read at a meeting of the company's officers. The president who knew a great deal about making silk but very little about making current spoke up:

"How much are these two machines going to cost?"

"Six thousand dollars—$3000 apiece set up and connected."

"Why do we need them?"

"To raise your power factor."

"Power factor! What is that?"

The engineer explained that induction motors had the same effect on the output of a generator as a leaky piston had upon the delivery of water by a pump. The flow lagged behind the pressure, because part of the pressure of the piston was applied to forcing some of the water back of the piston instead of into the pipes. The ratio of the water the pump delivered to the water it should have delivered was power factor of the pump. The synchronous condenser had somewhat the same effect as fitting an air-chamber to the pump. It stored up flow during the pump stroke and released it at the end of the stroke. (It was a crude simile but at least understandable.)

"Well, what work does the condenser do?"

"What do you mean, I told you what it does."

"I mean what does it drive?"

"Nothing; it just runs."

"You mean to say we spend $6000 for something that just runs. Nothing doing."

The engineer did some quick mental arithmetic. The first floor head-shaft was just outside the engine room. He would split the head-shaft and drive each half with one of the condensers. Each was good for 75 hp. of mechanical work without greatly impairing its main purpose. He explained this to the president, who was satisfied that he was getting something for nothing and authorized the purchase. The motors purchased for the first floor were turned in to apply on the cost of the condensers.

The final over-all power factor with the condensers in operation was slightly over .85. In dollars and cents the balance was as follows:

2 Synchronous condensers @ $6000.

Saving in penalty payments per annum	$ 5,400.00
Saving in purchased power by bringing the generator up to rating; 3000 kw.-hr. a day at 2½ cents = $75 a day. In one year	22,500.00
Total	$27,900.00

The whole cost of installing the condensers was therefore recovered in three months. Thereafter they earned very substantial dividends.

A Floating Synchronous Motor

Another interesting instance of the use of the synchronous motor principle to increase power factor while performing useful work is also drawn from the textile industry. The plant is a cotton mill in the Rhode Island-Massachusetts district. While the new cotton-mills in the South are electrified as a matter of course, since the high tension distribution of power has been highly developed in that section, the New England mills are being converted only gradually and the system of motor drive has not been standardized.

In the preparatory department containing the breakers, pickers, cards and lappers the group drive is used almost exclusively. The roving, spinning and twisting frames are driven (a) by individual motors, (b) by special motors belted to four frames each or (c) by single motors driving larger groups through line shafting. There is a great variation in the size of the group-drive motors and the number of frames to which they furnished power. One hundred horsepower motors are not uncommon.

The same is true of the looms. A single weave shed may contain 2500 looms in a fairly large mill. The cost of fitting so many looms out with individual motors is so great (probably $250,000) that the group drive is almost universally used.

For this reason the power factor condition is not as bad as in the silk-mill in our first illustration. But it is bad enough, ranging, generally between .50 and .60.

A visitor who knows something about the subject entered the engine room of the cotton-mill in point and happened to glance at the power-factor indicator on the switchboard. It registered 1.00. He remarked to the superintendent who was showing him around that the indicator did not seem to be working.

"Oh, yes, it is," replied the superintendent, "we always keep it at or near 1.00."

This is the way it was done. There were two mill groups almost identical in size and each complete in itself. One was mechanically driven through line-shafting by a cross-compound Corliss engine of 1500 hp. The other group had been motorized, current being supplied by a high-pressure turbo-generator of about the same capacity. Of course, induction motors were used exclusively. As originally installed the power factor had been .625, and the generator could barely carry the load. The installation of additional equipment in both mill groups called for either more power or an increase of efficiency which would enlarge the capacity of the existing units. The Corliss was loaded to the limit so the possibilities were limited to the turbo-generator.

The manager of the company which owned the mill, had some knowledge of electrical equipment, besides being possessed of unusual mechanical ingenuity. He devised the scheme shown on the sketch, Fig. 2.

After laying it out he submitted it to representatives of several manufacturers of electrical equipment who unanimously advised him that it could not be done.

So he went ahead and did it.

He purchased a 700-hp. synchronous motor and set it up as shown. It was belted through a counter to the head shaft driven by the Corliss engine. It was wired to the same bus-bars as the turbo-generator, as shown in Fig. 2.

The principle is this: As a synchronous motor floating in the line it serves to increase the power factor of the whole electrical system to 1.00 or thereabouts. If the Corliss cannot quite carry any temporary increase in the load in Mill No. 1 the motor draws current from the turbo-generator and delivers mechanical power to the head shaft, automatically making up the deficiency.

On the other hand, it sometimes happens that Mill No. 1 is running light while Mill No. 2 is drawing heavily on the generator. In that event the motor becomes a generator driven by the Corliss and supplies additional current to the bus-bars as needed. Besides it serves as a sort of emergency break down unit in case either prime-mover

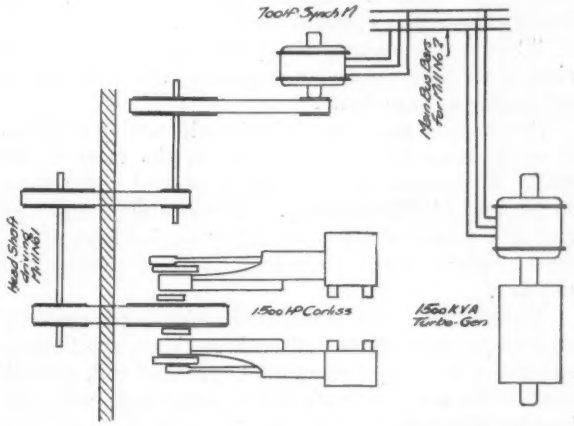


FIG. 2. FLOATING A SYNCHRONOUS MOTOR BETWEEN AN ENGINE AND A TURBO-GENERATOR

goes out of commission, as has happened several times. Instead of one mill unit being entirely shut down, it has only been necessary to select certain sections of each for curtailment, so that rush or special orders could be gotten out.

The motor, therefore, served a fourfold purpose:

(a) As an auxiliary to the steam engine,
(b) As an auxiliary to the turbo-generator,
(c) As a power-factor booster,
(d) As an emergency power unit for either mill.

Another Example

In industries other than the textile, it is often possible to find applications for a sufficient aggregate horsepower of synchronous motors in the main and auxiliary processes to obtain the necessary power factor correction without going to the expense of purchasing extra equipment.

The planing mill referred to, in the early part of this article is a case in point. It was one of the departments

in a plant devoted to the manufacture of road-builders equipment: wagons, scrapers, trench-diggers, etc. When the plant was motorized the distribution of the connected load was as follows:

1. Machine shop	215	hp.
2. Planing mill	390	"
3. Foundry	75	"
4. Assembling and finishing	100	"
5. Elevators and miscellaneous	90	"
Total	870	"

Of these the machine shop load was constant and approximated full load; the elevators were nearly always operated at full load. So was the foundry where the motors were on the cranes and blowers. The planing mill and assembling room demand, on the other hand, was seldom over one-half the connected load; generally it was one-third. The resultant power factor was .70.

This was hardly low enough to justify additional equipment to increase it. Tests and calculations developed that about 80 hp. of synchronous motors would correct the power factor to .90. The only possible applications for synchronous motors were the exhaust fans in the planing mill and the blower in the foundry. The former required two 35-hp. motors and the latter a 40-hp. motor. The foundry blower was operated about 4 hr. a day.

When it was running the power factor was .95 and when it was idle the factor dropped to .85 which was a satisfactory average figure.

Synchronous motors are built for self-starting by means of squirrel-cage induction bars set in the faces of the poles. This means that they can be started under 15 to 25 per cent of full load only. Therefore they cannot be used on machines which must start under full load, nor on those requiring variable speeds or frequent starting and stopping.

Moreover, the friction load of line-shafting is generally over 25 per cent of the full load, so that a synchronous motor used for this purpose must be provided with a clutch to allow the motor to reach full running speed before the load is thrown on.

These motors can be used to drive pieces of apparatus whose load is proportional to the speed, as fans and blowers; or for those which can be unloaded during starting by means of bypasses, as compressors and pumps. Again, they can be connected to machines which would naturally start light as grinding mills of various kinds, roll-stands for rolling rods and the like, rock-crushers, paper and pulp macerators, etc., and of course they can be used for operating other electrical apparatus as motor-generator sets and converters.

In actual operation synchronous motors often show a greater efficiency than induction motors. Therefore, while the starting is somewhat more complicated than for induction motors, they may be used with the assurance that they can compete with squirrel cage motors from the efficiency standpoint.

CORRECTION NOTE. In listing the equipment used in the new power plant of the Crossett Lumber Co., on page 789, August 1 issue, an error was made in connection with the safety valves. These were Consolidated safety valves furnished by Manning, Maxwell & Moore, Inc.

Developed and Potential Water Power of the U. S., 1924

THE GEOLOGICAL Survey, Department of the Interior, has just brought up to date its record of developed water power in the United States, which shows that there are now about 3211 water-power plants of 100 hp. or more, having a total installed capacity of 9,086,958 hp., an increase of about 1,160,000 hp., or nearly 15 per cent over the total in 1921, which was 7,926,958 hp. Of the present total, 7,348,197 hp., or 81 per cent, is in 1390 public-utility plants and 1,738,161 hp., or 19 per cent, in 1821 manufacturing plants. The corresponding percentages in 1921 were 78 and 22.

New York, with 1,542,983 hp., is still the leading State in developed water power, but California, with 1,451,830 hp., is a close second.

Water-power development in the New England, East North Central, West North Central, and Mountain States has not kept pace with that in other parts of the country, as the following table shows.

PERCENTAGE OF TOTAL DEVELOPMENT IN UNITED STATES

Division	1921	1924
New England	16.5	15.3
Middle Atlantic	18.7	19.1
East North Central	9.3	9.1
West North Central	5.6	5.1
South Atlantic	13.6	14.3
East South Central	3.1	3.8
West South Central	.2	.2
Mountain	10.4	9.7
Pacific	22.6	23.5

POTENTIAL WATER POWER

New estimates have been made of the potential water power resources of the United States, including Alaska, Porto Rico, and Hawaii, which it is physically feasible to develop under present conditions. Absence of market for power and inability to obtain necessary legal rights will delay development but should not prevent it. Figures given in the estimates show the 24-hr. power available 90 per cent of the time and 50 per cent of the time at 70 per cent overall efficiency at both developed and undeveloped sites.

In many of the reports from which the data were taken the estimates of potential power include the use of stored water for generating power. For districts where reservoirs are already built or where detailed field examinations show that such storage is feasible, these estimates have been used. All plans filed with the Federal Power Commission by applicants for permits to develop power on Colorado River show that power development on this river will include the use of stored water. This estimate therefore assumes that stored water will be used to equalize as far as possible the flow of the Colorado River below the mouth of the Green River. The estimate includes half of the potential power of the Niagara River and of the international section of St. Lawrence River, though an international agreement is necessary to permit the full use of these resources.

Washington stands first among the States in potential water power, for power available both 50 per cent of the time and 90 per cent of the time. She is followed closely, however, by Oregon, California and New York. A large proportion of the potential power in New York is available

POTENTIAL WATER-POWER RESOURCES OF THE UNITED STATES

Division	Available 90 per cent of the time Horse-power	Per Cent	Available 50 per cent of the time Horse-power	Per Cent
United States	34,818,000	100.00	55,030,000	100.00
New England	998,000	2.87	1,978,000	3.60
Middle Atlantic	4,317,000	12.40	5,688,000	10.35
East North Central	737,000	2.12	1,391,000	2.53
West North Central	871,000	2.50	1,844,000	3.35
South Atlantic	2,476,000	7.11	4,464,000	8.11
East South Central	1,011,000	2.90	2,004,000	3.64
West South Central	434,000	1.25	888,000	1.61
Mountain	10,736,000	30.83	15,513,000	28.19
Pacific	13,238,000	38.02	21,260,000	38.63
Alaska	1,000,000		2,500,000	
Porto Rico	19,000		28,000	
Hawaii	100,000		200,000	

continuously, due to the equalization of the flow of Niagara and St. Lawrence Rivers. The same is true of Arizona, whose water-power resources are mainly on Colorado River, where the flow can be controlled.

Relation of Present Development to Future Possibilities

Percentage of the total potential power of the United States that has already been developed can be estimated only in a rough way. The capacity of water wheels at developed sites in Maine, New Hampshire, Vermont and Massachusetts amounts to 131 per cent of the power available 50 per cent of the time at those sites. The wheel capacity in Massachusetts is nearly double the potential power for 50 per cent of the time at 70 per cent efficiency. A considerable percentage of the water power developed in these four States is used in industries where the power is required only 8 to 12 hr. a day, with pondage at the power plant sufficient to store the stream flow at ordinary stages when the plant is not operating. This condition results in a large overdevelopment of equipment in many plants. The developed sites in Canada from coast to coast have an average wheel installation 30 per cent greater than the power available during the six months of greatest flow. It will be many years before all the water-power sites in the United States are developed to a greater extent than the sites that have been utilized in the four New England States. Assuming that all sites may eventually be developed to a point where the wheel capacity is 131 per cent of the power available 50 per cent of the time, it may be said that the installed capacity will reach 72,000,000 hp. The present installed capacity of plants of 100 hp. or more is 9,087,000 hp., and on this assumption of the ultimate installed capacity, about 12.5 per cent of the potential water power of the country has now been developed.

How a Milwaukee Pumping Station Handles Coal

Describing the Coal Handling Equipment at the Riverside Pumping Station at Milwaukee. By N. L. Davis*

MILWAUKEE, the metropolis of Wisconsin, and a city of 575,000 people, consumes 70,000,000 gal. of water daily. Lake Michigan is the source of this water supply. The Riverside Pumping Station, recently put in operation, furnishes the pressure by which 35 per cent of this volume of water is transferred from the source to the consumers throughout the city. Upon completion, Milwaukee will be largely dependent upon "Riverside" for its water supply.

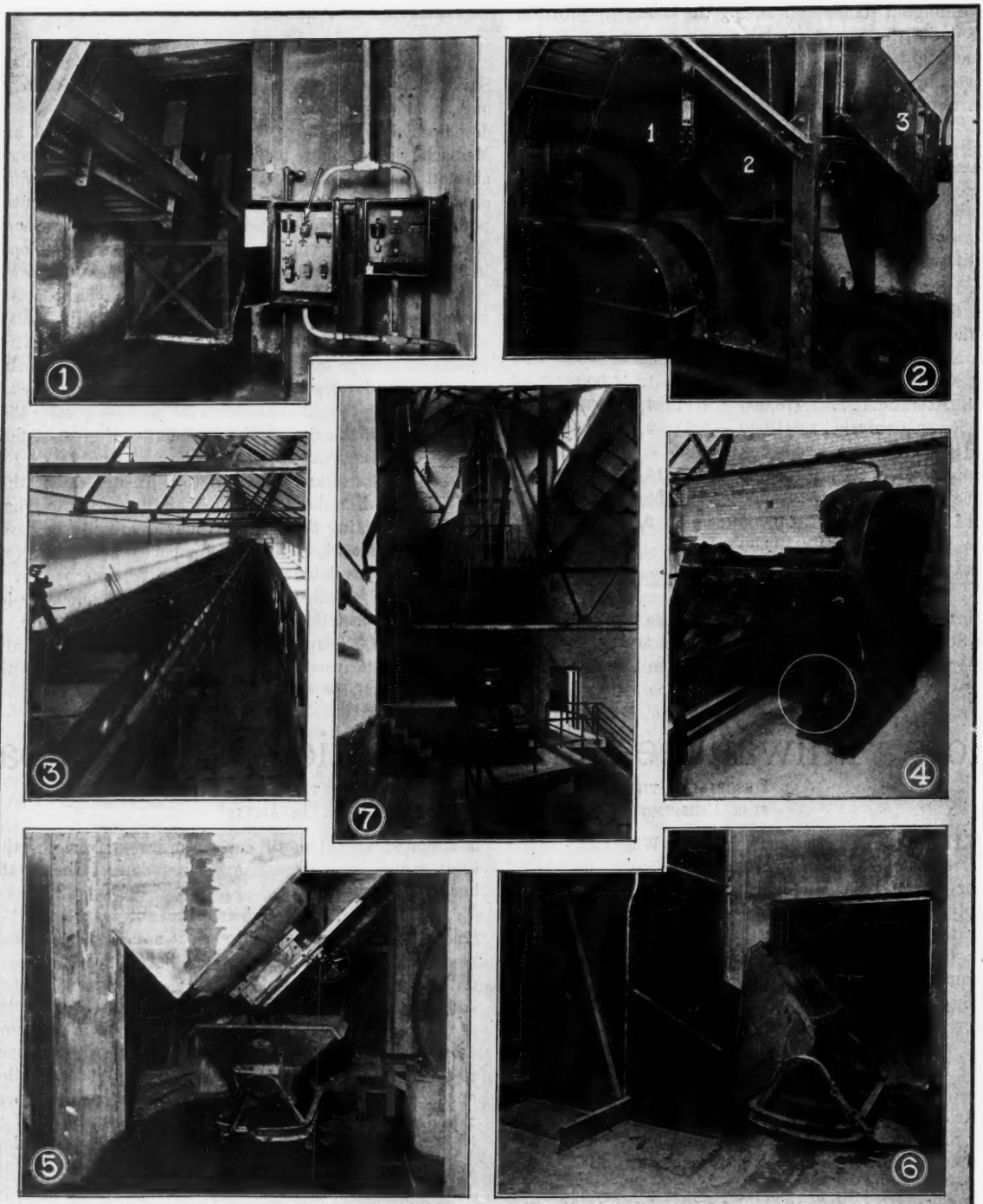
To carry this responsibility successfully, Riverside must be assured of continuous, night and day, operation. Since such operation is entirely dependent upon an adequate supply of coal, the machinery for the handling of the coal must possess an extraordinary flexibility. Because the completed system does possess extreme flexibility, we describe it herein.

Being located some distance from a railroad, all coal is carried to the pumping station in motor trucks of 5 to 7 T. capacity. With only one of the 6 ultimate units installed the coal consumed is now only 15 T. a day, although the ultimate consumption will be in excess of 80 T. daily.

Coal is dumped into a dump hopper covered by a steel grating over which the motor trucks drive. A steel apron conveyor removes the coal from this dump hopper, for further delivery to the crusher or conveying system. This apron conveyor is shown in Fig. 1 together with the electrical control boards and on which (indicated by arrow) is mounted an automatic cut-out operated from the time limit switch located on the driving end of the pivoted bucket carrier.

The bulk of the coal being brought to the plant by trucks instead of in railroad cars, it appeared to the engineers of the City of Milwaukee that in all probability, unless special means were provided, the carrier and coal handling system would be running idle a large percentage of the time. Allowing a coal handling system to operate 5 or 10 min. overtime on a 50-T. supply would not amount to much in percentage of over-run time. Such an allowance made to the small 7½-T. truck loads, however, means that on every load the machinery might operate 50 per cent overtime. This overtime percentage when calculated on a yearly basis would prove excessive in power costs. For this reason, a time limit switch was devised and operated from the drive shaft of the Peck Carrier, so that the coal handling system would operate over an interval of time sufficient to remove 7½ T. from the receiving hopper and deliver it to the farthest section of the overhead bunker, whereupon the whole system would automatically cease operation. More briefly stated, the operator, after the truck has dumped its load, presses a push button, thus starting the coal handling system. The coal is then delivered to the overhead bunkers, after which it automatically stops and awaits the next load of coal. A diagram of the time limit switch used in connection with this system is shown in Fig. 10. This device, as may be noted,

*Engineer, Link-Belt Co., Chicago.



VIEWS OF THE COAL HANDLING EQUIPMENT AT RIVERSIDE PUMPING STATION

Fig. 1. Coal is first delivered to this apron conveyor. Arrow indicates the automatic cutout operated by the time limit switch shown in Fig. 4. Fig. 2. From the apron conveyor the coal may be sent either of three ways, to the crusher, to the conveyor direct or to industrial cars, the paths being indicated by the number 1, 2 and 3, respectively. Fig. 3. The upper run of the pivoted bucket conveyor, where the automatic tripping device unloads the buckets into the coal bunkers. Fig. 4. The driving mechanism of the conveyor, showing the time limit switch box in the circle. Fig. 5. Ash from the ashpits is delivered to industrial cars in the basement of the boiler room. Fig. 6. The industrial cars discharge ashes into the receiving hopper of an electric skip hoist which carries it to the ash bin. Fig. 7. A view of the upper end of the skip hoist showing the driving mechanism. Safety devices to prevent a man from falling in receiving hopper or getting caught in pit are used.

consists of a worm driving a large wheel to which is attached a pin which trips open the switch which stops the conveyor during each revolution. The speed of the large wheel is geared down so that an entire 8½-T. truck load can be delivered to the bunkers during a complete revolution.

From this apron conveyor the coal is discharged into a three-way receiving spout which can be seen in Fig. 2. Here the coal, (if it is not of steam size) can be sent through a two-roll crusher, which crusher feeds to the lower run of the Peck Carrier. However, should the coal be of steam size it is not necessary to operate the crusher, but can be bypassed around the mechanism and directly to the Peck Carrier. This bypass is indicated by the numeral "2" in the illustration. As an emergency measure, for use only in the event that the conveyor is out of

Overhead Bunkers Are of Large Capacity

The overhead bunkers are of reinforced concrete construction and have a capacity considerably in excess of that ordinarily found. This is to provide for a coal reserve, the only means Riverside has for coal storage. To prepare against fire or spontaneous combustion in this overhead storage, and to provide a means for putting such a fire out by turning the coal over, portable steel chutes were made a part of the coal handling equipment. These chutes shown in Fig. 8 can receive the coal drawn from the overhead bunkers and deliver it, directly downward, through the boiler room floor to the lower run of the conveyor, when the coal would be returned to the bunker. Thus the stored coal can be turned over, which action in itself will put out any possible fire or eliminate the possibility of internal heat. This, in our belief, is the cheapest and

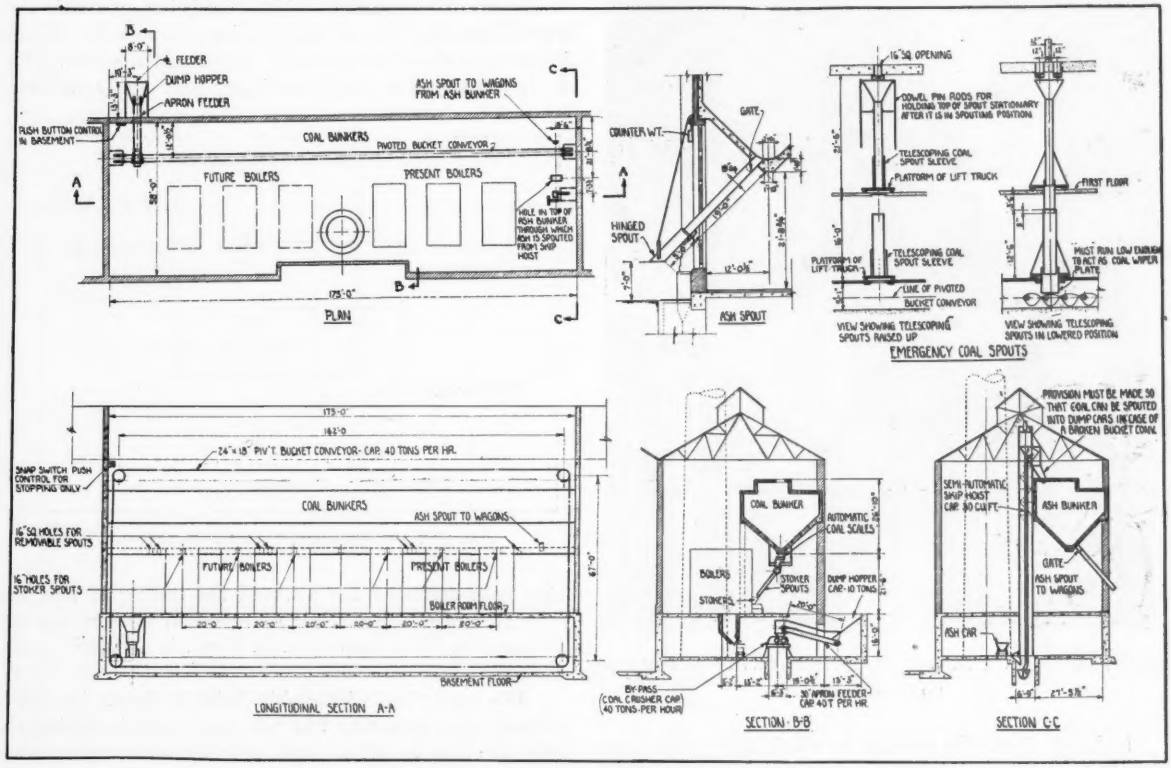

FEEDER
DUMP HOPPER
APRON FEEDER
PUSH BUTTON CONTROL IN BASEMENT
ASH SPOUT TO WAGONS FROM ASH BUNKER
COAL BUNKERS
PIVOTED BUCKET CONVEYOR
FUTURE BOILERS
PRESENT BOILERS
HOLE IN TOP OF ASH BUNKER THROUGH WHICH ASH IS SPOUTED FROM SKIP HOIST
175'-0"
PLAN
COUNTER WT.
GATE
HINGED SPOUT
ASH SPOUT
16"SQ OPENING
DOWEL PIN RODS FOR HOLDING TOP OF SPOUT STATIONARY AFTER IT IS IN SPOUTING POSITION
TELESCOPING COAL SPOUT SLEEVE
PLATFORM OF LIFT TRUCK
FIRST FLOOR
PLATFORM OF LIFT TRUCK
TELESCOPING COAL SPOUT SLEEVE
LINE OF PIVOTED BUCKET CONVEYOR
MUST RUN LOW ENOUGH TO ACT AS COAL WIPER PLATE
VIEW SHOWING TELESCOPING SPOUTS RAISED UP
VIEW SHOWING TELESCOPING SPOUTS IN LOWERED POSITION
EMERGENCY COAL SPOUTS
175'-0"
162'-0"
24"x18" PIV'T BUCKET CONVEYOR- CAP. 40 TONS PER HR.
SNAP SWITCH PUSH CONTROL FOR STOPPING ONLY
COAL BUNKERS
ASH SPOUT TO WAGONS
16"SQ HOLES FOR REMOVABLE SPOUTS
16" HOLES FOR STOKER SPOUTS
FUTURE BOILERS
PRESENT BOILERS
BOILER ROOM FLOOR
67'-0"
BASEMENT FLOOR
LONGITUDINAL SECTION A-A
COAL BUNKER
AUTOMATIC COAL SCALES
BOILERS
STOKERS
STOKER SPOUTS
DUMP HOPPER CAP.-10 TONS
BY-PASS (COAL CRUSHER CAP.) 40 TONS PER HOUR
36" APRON FEEDER CAP. 40 T PER HR.
SECTION B-B
PROVISION MUST BE MADE SO THAT COAL CAN BE SPOUTED INTO DUMP CARS IN CASE OF A BROKEN BUCKET CONV.
SEMI-AUTOMATIC SKIP HOIST CAP. 50 CU.FT.
ASH BUNKER
GATE
ASH SPOUT TO WAGONS
ASH CAR
SECTION C-C

FIG. 8. DETAILS OF COAL HANDLING SYSTEM

operation, bypass "3" is used. If, for any reason, the conveyor should become inoperative, the coal being discharged from the steel pan apron feeder can be spouted in a third direction which leads directly to industrial cars. After, in the industrial cars the coal can be wheeled either to the skip hoist or the platform elevator for delivery overhead. This is one of the ways Riverside eliminates improbable emergencies and assures itself continuity of operation.

Figure 3 illustrates the overhead run of the conveyor, where the coal is discharged to the concrete bunkers. Driven by a 10-hp. motor, this conveyor operates on 167-ft. horizontal centers and 66-ft. vertical centers, the individual buckets being 24 by 18 in. The driving mechanism is shown in Fig. 4, the circle indicating the time limit switch box previously referred to.

most practical method of eliminating this condition. No such fire has yet occurred, nor is one expected, but the chute, supplied at small additional expense, is there ready for service, just as a fire hose or chemical extinguisher, in case of emergency.

At present, with only three of the ultimate six boilers installed, three of the overhead bunkers are used solely for storage purposes. This stored coal, when needed, is obtained through the use of the emergency chutes.

Figure 9 shows the boiler room interior. It is apparent from this photographic reproduction that the power station is not fully completed. Indeed, at the time this picture was taken only one boiler of the three shown was in operation, the battery of three boilers for the opposite end of the room being yet to install.

Coal Weighed by Individual Scales

Coal drawn from the storage bunkers overhead is accurately weighed with individual scales before it is passed to the stoker magazine. Considerable thought was given to this matter by the city's engineers and it was decided that each boiler would be handled independently and that accurate records be kept of the weight of coal consumed by each. Individual Richardson scales, 200 lb. capacity, automatic belt feed were decided upon because this equipment affords accurate though completely automatic weight of all coal used. It is almost impossible, according to the engineers, to get men who will always keep their records properly separated, as is necessary in the use of a traveling weigh larry. Through the installation of the individual scales the boiler room was completely automatized.

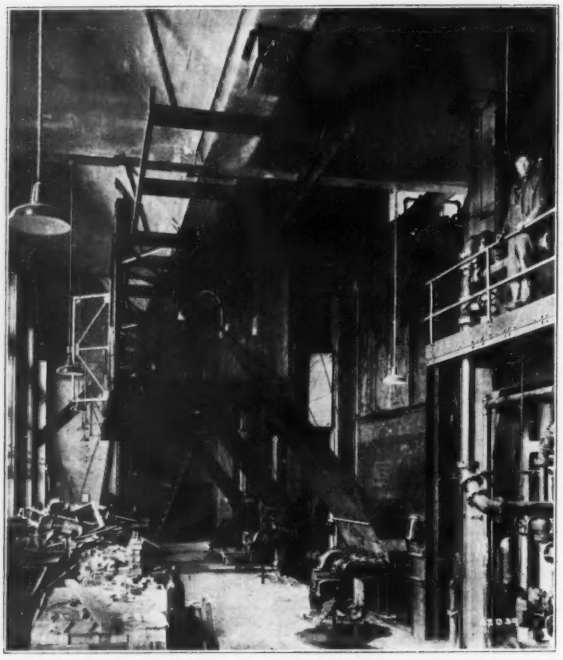


FIG. 9. VIEW IN THE BOILER ROOM SHOWING AUTOMATIC COAL SCALES

Figure 9 shows the manner in which these scales were individually mounted. Each is protected by a cage which prevents their being tampered with. The entire platform can be rolled to one side when the boiler chutes are being removed, or for any purpose that makes necessary the removal of the scales.

Ash Removal

Ashes are deposited from the boilers to concrete ash pits illustrated in Fig. 5. From these hoppers, the ashes are discharged to industrial cars in which they are carried by means of hand lift trucks to the skip hoist receiving hopper shown in Fig. 6. The bucket of this skip hoist is of 30 cu. ft. capacity, the travel being 80 ft. The top of the skip is shown in Fig. 7.

If for any reason the skip hoist should become inoperative, the ashes can be delivered to the overhead ash hopper by means of the pivoted bucket conveyor or through the use of the platform elevator which could lift the industrial cars to the proper level for dumping, by hand, into the ash hopper. The ash storage hopper leads to the truck driveway, where, upon occasion, the truck bringing the coal can be used to carry away the ashes.

Provisions For Safety

Two elements of danger to workmen were avoided in the design of this skip hoist. One—the possibility of a man falling into the receiving hopper; the other—the hoist being put into operation while a man was in the pit doing any sort of work. The first possibility was eliminated through placing a hinged cover plate over the mouth of the hopper and extending the casing of each end of the hopper to prevent a man tumbling into it in the dark. Furthermore, when the hinged cover plate over the hopper is raised the skip hoist cannot be operated until the man handling the ashes lowers that cover plate and pushes the starter button.

To prevent against the skip hoist being operated while a workman might be in the pit, the skip hoist is rendered inoperative when the trap door (shown at the left of Fig. 6) is raised. This trap door is the only way a workman

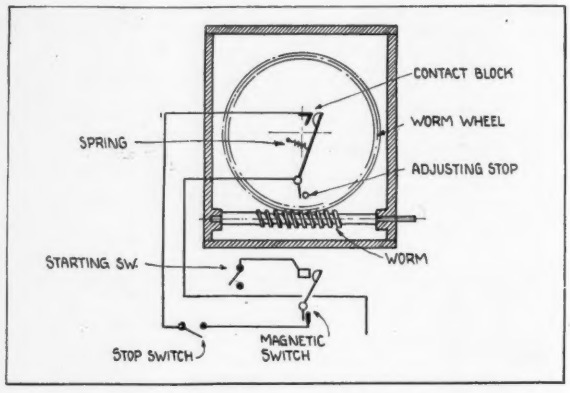


FIG. 10. DIAGRAM OF TIME LIMIT SWITCH

may gain access to the pit, and the raising of this trap door throws off all electric current and renders the skip inoperative. The trap door, in itself, is a positive safety feature.

The upper end of the skip hoist is shown in Fig. 7. Considerable ingenuity was necessary when installing this skip in order to get it fitted properly without the necessity for cutting a truss. The chute leading from this hoist is a two-way affair, so that it is possible to chute ashes to either the carrier or the industrial cars.

Cleaning Air Receiver Piping

It usually happens that oil, carbon and other foreign matters are deposited in air discharge lines and air receivers. A practical method of cleaning these is to fit a receptacle made of 5 or 6-in. pipe on top of the discharge pipe. If a mixture of 1 lb. of red seal lye and 18 lb. of water is passed into the discharge line at the rate of 60 or 70 drops per minute while the compressor is running, it will clean out all the accumulation on the surface of the pipe and in the receiver and if the blowoff valve on receiver is opened, all of this foreign matter will be discharged therefrom. This cleaning solution should be used every month or oftener, depending on how much accumulation there may be in the receiver.

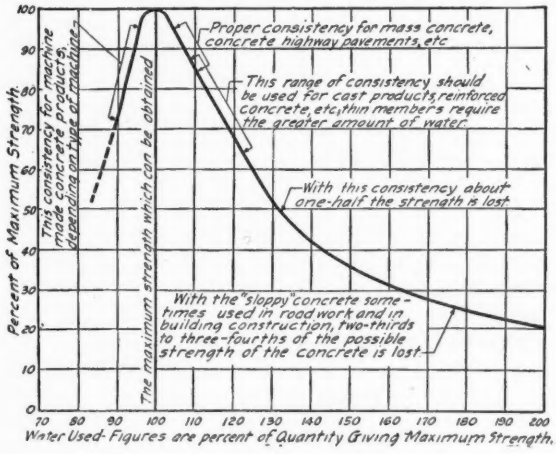
Mixing Concrete for Power Plant Use

MANY USES ARISE AROUND THE POWER PLANT WHERE CONCRETE, PROPERLY MADE, AFFORDS EXCELLENT CONSTRUCTION

COMMON PRACTICE in the use of concrete for building foundations requires that it be proportioned on the basis of 1-3-5. This means that the ingredients making up the concrete must consist of 1 part of Portland cement, 3 parts of sand and 5 parts of gravel or coarse aggregate. All of these must be proportioned by volume and not by weight. The strength of concrete depends primarily upon the amount of water used in mixing it, the grading of the aggregates, accurate measurement of the aggregates, thorough mixing and clean and standard materials.

Excess mixing water weakens concrete. Sloppy mixtures sacrifice strength. One pint more water than necessary in a one-bag batch decreases the strength and resistance to wear of concrete as much as if 2 or 3 lb. of cement were left out. The quantity of mixing water is just as important as the quantity of cement.

Given herewith is a curve which shows the effect of the quantity of mixing water on the strength of concrete.


Percent of Maximum Strength
100
90
80
70
60
50
40
30
20
10
0
70 80 90 100 110 120 130 140 150 160 170 180 190 200
Water Used- Figures are percent of Quantity Giving Maximum Strength.
The maximum strength which can be obtained
This consistency for machine mixed concrete products, dependent on type of machine
Proper consistency for mass concrete, concrete highway pavements, etc
This range of consistency should be used for cast products reinforced concrete, etc, thin members require the greater amount of water
With this consistency about one-half the strength is lost
With the "sloppy" concrete sometimes used in road work and in building construction, two-thirds to three-fourths of the possible strength of the concrete is lost

EFFECT OF QUANTITY OF MIXING WATER ON THE COMPRESSIVE STRENGTH OF CONCRETE

It is an average of the results obtained with many mixtures and aggregates.

In general construction work, maximum strength can seldom be secured because the mixture would be too stiff to be workable but 70 to 90 per cent of the maximum strength can readily be obtained. This would be a great increase over the usual results, since much of the concrete placed today contains 50 to 100 per cent more water than necessary and thus attains only half or even only a quarter of its possible strength.

Mixtures for reinforced concrete must usually be more plastic than for mass concrete or for pavements. Therefore, more mixing water is needed and the required strength can be obtained only by using more cement. Obviously, it is economy to limit the quantity of mixing water to the smallest possible amount.

Consistency is easily measured and regulated by the "slump test." Through its use on the job the quantity of mixing water used in the concrete can be controlled fairly closely. The only apparatus needed is a sheet-metal form, shaped like a frustum of a cone, 4 in. in dia. at the top, 8 in. at the bottom and 12 in. high and a ⅝ in. pointed metal rod 21 in. long.

Fill this form with the concrete to be tested, placing it in layers about 4 inches deep and working it with the pointed metal rod. In order to secure uniform results, specifications of the American Society for Testing Materials state that each layer should be rodded exactly 30 times. Lift off the form immediately and measure the settlement or slump of the concrete.

Concrete having a slump of ½ in. to 1 in. will contain only a little more water than necessary for maximum strength but will be too stiff for most construction work. The following table shows amount of slump recommended:

Type of concrete	Maximum slump recommended
Mass concrete	2 in.
Reinforced concrete—	
Thin vertical sections	6 in.
Heavy sections	2 in.
Thin confined horizontal sections	8 in.
Roads and pavements—	
Hand finished	4 in.
Machine finished	1 in.
Mortar for floor finish	2 in.

Water tight concrete means good concrete. A few fundamental principles of good construction should be carefully observed. These can be summarized as follows:

1. All portions of the structure should be strong enough to resist the head of water, either internal or external, to which the concrete may be subjected.
2. Use clean, well graded aggregates.
3. Use a relatively rich mixture, a 1:2:3, or better 1:1½:3.
4. Use the minimum amount of mixing water that will give a workable, plastic consistency; not over 6 gal. per sack of cement.
5. Mix the concrete thoroughly, at least 1½ min. per batch mixer.
6. Place the concrete carefully in layers 6 to 12 in. deep, spading or rodding it thoroughly to prevent the formation of stone pockets or voids.
7. If possible place the concrete in one continuous operation to avoid construction joints. If placing is interrupted, be sure to get a good bond between the fresh concrete and that placed previously.
8. Keep the concrete warm and damp for the first ten days.

PROPORTIONS DEPEND ON AGGREGATES

Concrete of substantially the same strength can be made from any combination of fine and coarse material, provided that the materials are properly proportioned. The mixture should be determined after a study of the particular aggregates to be used. If the grading of the aggregate changes during the progress of the work, it is an easy matter to change the mixture accordingly.

Numerous tests have been used for determining whether or not a sand possesses the requisite cleanness for use in concrete. The most common tests which have been used for this purpose are the determination of silt and the loss in weight resulting from heating the sand to a red color (ignition test). The silt test gives a measure of the amount of fine material, generally clay or loam, which is contained in the sand but furnishes no information as to the probable effect of such materials on the strength and durability of concrete or mortar made from the sand.

Method For Field Test

Field test for organic impurities consists of shaking the sand thoroughly in a dilute solution of sodium hydroxide (NaOH) and observing the resultant color after the mixture has been allowed to stand for a few hours. Fill a 12-oz. graduated prescription bottle to the 4½-oz. mark with the sand to be tested. Add a 3-per cent solution of sodium hydroxide until the volume of sand and solution, after shaking, amounts to 7 oz. Shake thoroughly and let stand for 24 hr. Observe the color of the clear liquid above the sand.

APPROXIMATE QUALITY OF MIXING WATER REQUIRED FOR CONCRETE

Mix		Approximate Mix as Usually Expressed			Water Required (Gallons per sack of Cement)	
			Aggregate			
Cement	Volume of Aggregate After Mixing	Cement	Fine	Coarse	Minimum	Maximum
1	3	1	1¼	2½	5	5½
1	4	1	1½	3	5½	6
1	4½	1	2	3	5¾	6¼
1	5	1	2	4	6	6½
1	6½	1	2½	5	7¼	7¾
1	7¾	1	3	6	8¼	8¾

If the solution resulting from this treatment is colorless, or has a light yellowish color, the sand may be considered satisfactory in so far as organic impurities are concerned. On the other hand, if a dark colored solution is produced, the sand should not be used in high-grade concrete such as that required in roads and pavements, or in building construction.

Thorough Mixing Increases Strength of Concrete

Two batches a minute from a concrete mixer gives a rapid output but sacrifices considerable strength in the concrete. Two batches a minute usually means a net time of mixing, after all the materials are in the drum, of only 15 sec. That is not enough for thorough mixing and will develop only part of the potential strength of the mixture. Moreover, concrete that has not been thoroughly mixed will not be uniform in quality: it is likely to contain stone pockets or voids which are weak spots and which may permit objectionable leakage.

Mixing the concrete for 5 min. will give an increase in strength. Five minutes is, of course, longer than would be feasible on most construction work but mixing for 1 to 2 min. after all materials, including water, are in the mixer drum is feasible and should be required.

Freshly placed concrete can be kept damp in several ways. Drenching the subbase and forms with water before concrete is placed will reduce absorption. Horizontal surfaces, such as floors and pavements, can be covered with damp sand the day after they are laid, when they have hardened sufficiently to prevent pitting the surface. Sometimes small dikes of clay are built around a section of floor or pavement, which is then flooded with water. Vertical surfaces can be kept damp by frequent sprinkling of the forms or exposed concrete. Sometimes walls are covered with canvas or burlap, which is drenched with water several times a day.

Keeping concrete damp the first 10 da. will give the owner over 65 per cent better value for his money. Three weeks' protection will give still greater increase in value. There is nothing that can be done to concrete that will pay such big dividends as proper use of water in mixing and in curing.

Efficient Burning of Fuel Oil

CONCISELY stated, the following are the general requirements for efficient oil burning: The oil must be finely atomized just prior to coming in contact with the air for combustion. The requisite quantity of air must be intimately mixed with the oil, and excess air reduced to a minimum. A high furnace temperature must be maintained, by the use of sufficient refractory surface to assist in complete combustion. The combustion must be completed before the gases of combustion come in contact with cooling surfaces and become chilled below the ignition temperature.

Boiler heating surfaces must be protected from localized heating caused by a blow pipe action; heating should be uniformly distributed.

Fineness of atomization is dependent on (1) the design and mechanical construction of the atomizers; (2) the proper straining of the oil; (3) the heating of the oil to the proper temperature.

Of primary importance to the operating engineer is the requisite viscosity to obtain the best atomization. The extent to which an oil may be atomized is not alone dependent upon the design of the atomizer but upon the viscosity of the oil as well. The thinner the oil the finer will be the atomization produced. The greater the viscosity, the more difficult it becomes for the atomizer to break up the oil into particles fine enough for its intimate mixture with the necessary air for combustion.

For those oils having a gravity of Baumé of 16 deg. (specific gravity 0.9589) and above, very little reduction in viscosity is gained by heating above 180 deg. F. Inasmuch as some atomizers will produce efficient atomization with oils at a viscosity between 8 and 10 deg. Engler (300 and 375 Saybolt seconds) there is no practical gain in heating the oil above the temperature that will give a viscosity between these limits.

In the case of the more viscous oils, it is neither desirable nor practicable to reduce this viscosity below this point, as to do so would require heating the oil to a temperature high above the flash point, which is a dangerous expedient unless extreme care is taken to guard against leaks in the oil lines.

In addition to objections cited to the heating of a very viscous oil to excessive temperatures may be added the space required for heaters of sufficient capacity, and also the danger of breaking down the oil, causing it to clog up the heaters and oil lines and to carbonize the atomizer.

Developments in Ice-Making Plants

Outline of Present Practice and Probable Development as Presented to the N. A. S. E. Convention. By Halbert P. Hill

DURING THE LAST 20 yr., the art of mechanical refrigeration in ice making has made considerable progress but unfortunately its development has been slow as compared to that of the steam turbine, Diesel engine, aeroplanes, automobiles, wireless, etc., for the fact that in most northern localities there was an abundance of natural ice, prices were low and cost of transportation reasonable. A certain amount of distilled water had to be made to make sufficient ice; therefore little attention was paid to the economy of the boilers and less attention to the economy of the engines, as in reality they acted as a reducing valve as well as producing power to drive the compressors. With the development of raw water ice, however, the question of power became serious. More attention was given to prime movers. Boiler plants, formerly operating at efficiencies varying from 45 to 60 per cent and in some rare instances 70 per cent, are now designed for real economy.

Ammonia compressors have passed through a period of evolution. The old slow speed, heavy valve type machine is rapidly being supplemented by the more modern high speed ring plate or feather valve type and the two-stage compound compressor is rapidly coming into general use. The development of the high-speed compressor has brought out improvements in electrical apparatus. It is only within the last few years that the application of synchronous motors direct connected to ammonia compressors has been in use.

Many of the old operating engineers labor under the fallacy that an ammonia compressor must operate at various speeds throughout the year to take care of the seasonable loads and demands and that a machine operating at one speed such as a synchronous motor drive, could not be used. This brought out the development of the clearance pocket whereby the cylinders are equipped with clearance pockets controlled by hand-operated valves so that the amount of clearance could be increased by steps, thus decreasing the capacity of the machine. Many machines are now equipped and capable of operating from 40 per cent of full load up to full load in several steps.

Compound compressors have many advantages. The work is divided between two cylinders, thus greatly reducing the duty on each cylinder; it lends itself more easily to electric drive and better volumetric efficiencies are obtained by intercooling between stages. Further a saving in power is made possible which in turn means a higher overall efficiency.

Many Changes Have Been Made in Condenser Design

Ammonia condensers, one of the most abused pieces of apparatus in an ice-making or refrigerating plant, have been designed in every conceivable shape and type imaginable. The atmospheric condenser is the type most generally adopted. The double-pipe condenser met with favor in many instances on account of the ability to install it on the wall of the engine room or in any convenient locality. The shell and tube condenser is one of the latest developments and has many advantages both from a standpoint of economy as well as ease of operation and long life. When properly installed it has a higher efficiency than other types of equipment. The shell and tube condensers are built both horizontally and vertically. The horizontal types are provided with heads usually divided in several passes for the water circulation.

While there are many most successful installations of the horizontal type, yet the vertical shell and tube condenser is much more efficient and where there is space to install it, it makes the ideal type of equipment; by admitting water at the top and providing each tube with an auxiliary saw-tooth removable tube, a constant water level can be maintained above the condenser tubes. The water flows down the tubes at a high velocity in a thin film covering the inside surface of the tubes and discharges in a pan or sewer connection at the bottom of the condenser. The condenser can be cleaned while in operation and the numerous installations that have been in operation more than 6 yr. prove the condensers require little or no repairs, that the life is exceptionally long and the efficiency extremely high. The test in question was on a 75-T. condenser which carried a 225-T. load with ease and economy. In another test a heat transfer of 315 B.t.u. was obtained with 4½ sq. ft. of cooling surface per ton of refrigeration.

Drying Air For Aerating Systems Is Difficult

Quality of the water has a material bearing on the clearness of ice manufactured. With good water, an ordinary drop pipe low-pressure air system can produce clear marketable ice. The main disadvantage is sucking of cores and removing the tubes, before they are frozen in, which is a labor problem. With high-pressure systems the air is kept on until the can is completely frozen up, and for this reason makes better ice with inferior water. Most of the high-pressure aerating systems are alike in principle and the main difficulty lies in drying the air; with a well-designed dehumidifying system a large part of this trouble is eliminated.

Various means have been devised for treating the water with a view of eliminating core sucking and there is an opportunity for greatly improving the various existing freezing systems. Experiments have been made by removing the solids in suspension by centrifugal force. Filtration has also been tried and while these systems do remove a large portion of the solids in suspension, yet the salts remain in the water and, of course, require sucking of cores. A number of experiments have been made by adding various compounds with a view of making clear ice without core pumping. So far none of these systems have proven commercially successful. A great deal of research work has been done with a view of improving the quality of ice and decreasing the time of freeze. One method in particular was effected by crimping the can at six points with the result that the time of freeze was decreased 14 hr. Certain objections were raised to a cake of ice with these indentations. This type of can, however, has possibilities as it is only a matter of a short time until the scoring of ice will be universal. Ice is now being scored by a number of manufacturers and there are several types of scoring machines on the market which are successful.

To carry out further these experiments to determine how much time could be saved in freezing, several other types of cans have been made. The first cans were made by soldering six 2 by 2-in. pieces in the inside of the can and then boring holes where the pieces were attached for brine circulation. This made a cake of ice weighing 270 lb. which froze in 28 hr. The next can was made by screwing ⅜ by 2-in. strips in the inside of the can and this froze in 32 hr. The disadvantage of this arrangement was that the heavy strips required a considerable time, practically 5 min. to thaw and after thawing, a cake of ice weighed only 292 lb. This led to the development of the can crimp with six 2 by ⅜-in. indentations. The can froze in 30 hr. and required 3 min. for thawing.

Possibilities of Supercooled Water

These experiments were carried further with a view of utilizing supercooled water for the manufacture of ice. It is interesting to note that water can be supercooled in an agitated state to a temperature as low as 27 deg. F. without crystallization taking place. Then by the introduction of the smallest particle of ice, supercooled water will flash, some ice crystals being formed and the rest of the water raised to 32 deg.

For instance, if water is cooled to 28 deg. and then allowed to flash, about 4 per cent will flash into ice and the balance will raise to 32 deg. In one of the experiments the supercooled water was discharged against the refrigerated surfaces of a trough but the crystals would not adhere to each other and the trough was filled with a mixture of ice crystals and water, which might be termed slush ice. This when frozen solid made opaque ice for the reason that crystals are surrounded by a film of water and this water contains air. Furthermore, the crystals were arranged with their axes in all directions and when frozen solid the light was reflected and refracted in all directions, so that the cake was white.

In another experiment a large steel can was made 6 ft. 9 in. long. Six feet of the surface was ammonia jacketed and the water was pumped in at the top and discharged at the bottom. Ice was made but the same difficulty was encountered, namely, that the ice crystals would not deposit in layers or laminations on the refrigerated side but the whole mass became slush ice and was opaque. Agitators were introduced in the can but the results were not satisfactory.

Comparison is interesting of the distilled water steam-driven ice-making plant of the past, with an efficiency of around 4½ T. of ice per ton of coal with the modern raw water steam-driven plant producing as high as 22 T. of ice per ton of coal, or with the electrically driven raw water plant operating as low as 35 kw.-hr. per T. of ice. It must be conceded that progress is being made.

Many ice manufacturers are laboring under the delusion that by driving their present compressor with a motor or by the installation of an aerating system, they have converted their plant to an electrically driven raw water ice-making plant and that they are obtaining economy. In most instances they have gained in economy but the modern plant of today means more than a motor to drive the compressor and some system whereby air is admitted in the can to make clear raw water ice.

Few freezing tanks have sufficient agitation and few are properly piped. For economy in freezing tanks you must have sufficient cooling surface, whether brine coolers or piping. If brine coolers, it has been found that 30 sq. ft. per T. of ice is none too much, yet there are many plants installed with as low as 18 sq. ft. and few above 25 sq. ft. Where coils are employed, they should be connected up so that the freezing tank can be operated flooded. This cannot be done unless means are provided to prevent slopping over and freezing back to the machine.

Introduction of accumulators set in the freezing tanks in a manner accomplished the purpose but the modern method is to provide an accumulator at a convenient point below the freezing tank, pipe it up with cooling coils and install an ammonia pump and operate the tank flooded. Then let the liquid slop over into the accumulator where the cooling coils will dry out the wet gases and the pump will pump the liquid to the high pressure side of the system. This cold liquid helps to cool the high pressure liquid and no refrigeration is lost. The use of an accumulator of proper size and properly installed prevents freezing back to the machine and allows operation at the maximum suction pressure.

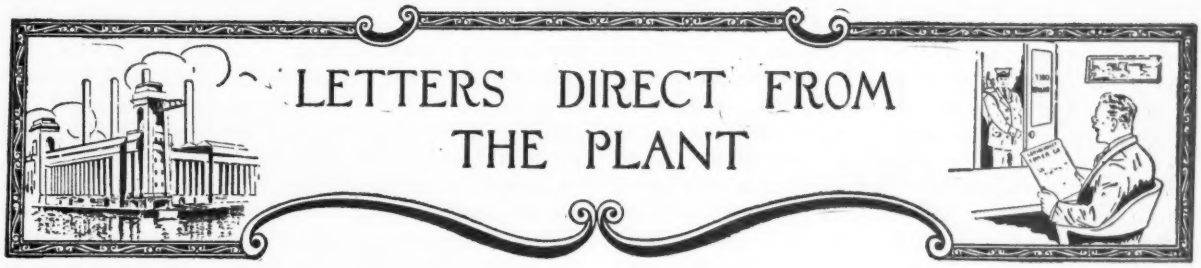
The above outline has been selected from a paper read at the N. A. S. E. Convention.

Troubles Encountered in Pump Operation

ONE COMMON source of trouble in pumping plants is the screen or strainer, particularly where the pump is handling water that is contaminated with foreign material, such as leaves and general accumulation that is found in most streams. The majority of strainers installed are too small, and a high velocity through the strainer will result in rapid clogging, as each and every particle that finds its way to the strainer, is held against the orifices by the velocity of the entering water, and thus cannot get away. This process goes on until the strainer becomes completely clogged. The clogging of the strainer can always be determined by placing a vacuum gage on the suction line and noting the vacuum necessary to fill the pump with water, which is the static head. If the vacuum increases after a period of operation, it is due to clogging of the strainer and the process of clogging can be noted by watching the vacuum gage. Strainers should be large enough to keep the velocity of the entering water extremely low, so that the natural current or movement of the surrounding water can prevent the collection of foreign matter on the strainer.

Another accessory to the centrifugal pump that is the cause of considerable trouble is the foot valve. It is not advisable to use a foot valve or check valve on the suction of a pump unless it is necessary to prime the pump by filling the piping and pump with water. If the pump can be primed by an ejector operated either by steam or water, it is preferable to omit entirely the foot valve or check valve on the suction, thus leaving the suction line entirely free. If a foot valve or check valve is used it must always be located below the water level.

It is usually advisable to install a check valve on the discharge line to prevent water flowing back through the pump in case of sudden stoppage of the driving motor.



Formation of Boiler Scale

In the editorial comment under the heading "Formation of Boiler Scale" in the Aug. 15 issue, I notice the following statement: "We may look forward to the development of methods for keeping boilers entirely free from scale." This development has already been made. It will no doubt be interesting to know that this was accomplished 10 yr. ago and that the same result has been obtained many times since and can be obtained at any time anywhere in any boiler plant.

At a plant where vertical bent tube boilers carrying 150 lb. pressure and operating at 200 per cent of rating were and are now being kept entirely free from scale, an analysis of the boiler water shows the following scale forming materials:

	Gr. per gal.
Silica	0.70
Organic matter	4.32
Calcium carbonate	7.29
Calcium sulphate	3.50
Magnesium carbonate	1.22
Magnesium chloride	3.61
Incrustants	20.64
Sodium chloride	9.15
Total solids	29.79

In this plant the boiler water is being treated in a lime and soda ash hot process softener.

The owners of the plant have operated their boilers continuously for periods of a year and have found them free from scale when opened.

Identical results have been obtained in a plant using harder water, an analysis of which shows:

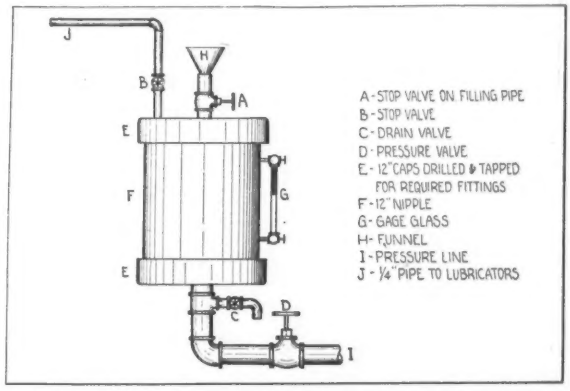
	Gr. per gal.
Silica	1.35
Calcium carbonate	12.00
Calcium sulphate	15.50
Magnesium sulphate	26.76
Incrustants	55.61
Sodium sulphate	1.56
Sodium chloride	3.04
Sodium nitrate	0.51
Total solids	60.72

Chicago, Ill. F. F. Vater.

Novel Lubricator Supply Device

In our plant, as in most plants of this size, we have a number of engine bearing and cylinder lubricators which must receive periodic attention. About an hour before my relief reports, it is my duty to make the rounds and fill them all with oil. However careful we might be, it was impossible to prevent a quantity from overflowing. The result was that considerable quantities were wasted.

To eliminate this trouble and waste, I installed an oiling device which saved considerable time and oil, at little expense. As shown in the accompanying sketch, the device consists of a length of 12-in. pipe (the length depending on the rate of oil consumption), two caps, a gage glass and the necessary ⅜- or ¼-in. pipe connections. This reservoir is connected at the top to the lubricators to be supplied and at the bottom to a source of water pressure. The water pressure serves to force the oil out at the top.


A - STOP VALVE ON FILLING PIPE
B - STOP VALVE
C - DRAIN VALVE
D - PRESSURE VALVE
E - 12" CAPS DRILLED & TAPPED FOR REQUIRED FITTINGS
F - 12" NIPPLE
G - GAGE GLASS
H - FUNNEL
I - PRESSURE LINE
J - ¼" PIPE TO LUBRICATORS

OIL IS FED TO LUBRICATORS FROM RESERVOIR UNDER HYDROSTATIC PRESSURE

To fill, close valves B and D and open valves A and C. Water is drawn off at C in a bucket or other waste receptacle. A new charge of oil is then introduced at A through the funnel, H. When the reservoir is full A and C are closed and B and D are opened again. The pressure line I may be connected to a source of steam pressure but in this case a water trap on loop should be used.

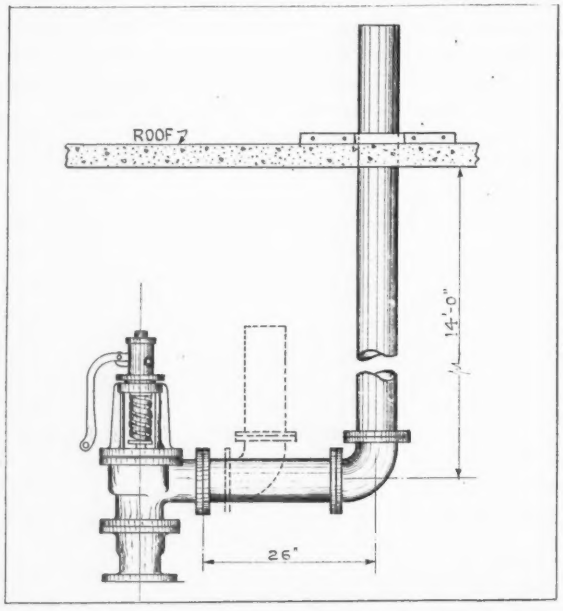
As different grades of oil are used in the cylinder and on bearings, separate reservoirs must be used for the two classes of service.

Des Moines, Iowa. G. B. Shaffer.

Safety Valve Must Be Free from Strain

One important requirement in the mounting of safety valves on boilers is the elimination of all strains on the body of the valve. Where strains are present leakage is likely to result. Such slow leaks are not only wasteful of steam but if allowed to continue will cut the seats and discs so that expensive repairs become necessary. This point is illustrated in an installation of two 3½-in. twin safety valves on a 400-hp. Stirling boiler. The valves

were set to relieve at 150 lb. boiler pressure and were bolted to the steam drum in the usual manner. In the discharge was screwed a piece of 4-in. pipe about 26-in. long, then a 90-deg. elbow and the pipe leading straight up through the roof of the boiler room. This was installed so that in case the boiler popped the relieved steam would blow out of doors and not fill the boiler room with steam, which was particularly objectionable in the winter time. A sturdy clamp was fastened around the pipe and rested on the concrete roof. This was supposed to take the weight of the pipe. After the boiler had been in operation a short period, all of the valves began to leak. They were removed, repaired and replaced. For a time they held tightly, then they began to leak again. The next time the valves were repaired, they were put up as shown by the dotted lines in the accompanying illustration. The valves have since been in service nearly 2 yr. and do not yet



REARRANGEMENT OF EXHAUST PIPING RELIEVES STRAIN

show any sign of a leak. The 4-in. exhaust pipe had been supported as rigidly as possible but it had settled slightly. Even the smallest settlement exerts an enormous leverage on the body of the relief valve which in turn had served to distort the seat and cause leakage. It was better to have the steam in the boiler room occasionally than to be bothered with continuous leaking and expensive repairs. The alteration proved to be a happy solution for what appeared to be a vexing problem.

Chicago, Ill. H. M. Toombs.

Combustion Control Based on CO_2

Mr. Gaster's letter in the Aug. 15 issue regarding control of air supply by apparatus operating on the percentage of CO_2 in the flue gases is correct in that the various items of furnace design have a material influence on furnace efficiency. My statement that efficiency of combustion is controlled solely by the condition of the fire would have been better had it been qualified explicitly as it was intended to be understood "for any one furnace."

The control of air supply by the CO_2 content of the flue gases in powdered fuel or oil burning furnaces is critical; they normally operate so nearly at the theoretical air supply, i. e. only 10 or 15 per cent excess air, that any material error in sampling or analyzing the flue gases would be likely to result in a deficiency of air supply with undesirable evolution of smoke and possibly large losses due to unburned gases. This is, I believe, not an idle or theoretical objection, as accurate sampling of flue gases in large boiler units with wide furnaces is a difficult problem and not yet satisfactorily solved in all cases.

Understand that at present air supply is being automatically regulated in proportion to fuel supply and steam demand but on a quantity basis as measured by the drop in draft pressure through boiler tubes or by damper opening rather than by flue gas composition, which with most present forms of apparatus would involve an undesirable time lag in the regulating apparatus.

Another feature which must be kept in mind in such regulations to avoid smoke, is that with increasing load the air supply must be increased in advance of the fuel supply and on dropping load the air supply must be maintained until after the fuel supply has been decreased.

A practical working difficulty, which Mr. Gaster may have overcome, is that all the usual forms of CO_2 recorders or indicators give but little power to operate a relay for controlling the air supply, and as practically the whole range of operation would have to be confined to a variation of 1 per cent of CO_2 above or below standard it will be seen that a slight friction drag in the mechanism would introduce wide variations in the results.

For these reasons, the influence of which will be to produce a much more complicated and expensive apparatus than one based on regulating the volume of air supplied either by an air meter using the resistance of the boiler tubes as an orifice or by a cam or linkage empirically regulated to open the damper in proportion to the fuel supply, I believe that effort expended along these lines with the use of CO_2 indicators or recorders as a check on their operation will ultimately produce greater return for the energy expended.

A great deal of work has already been done along these lines and the subject is ably discussed in Mr. Piggott's recent A. S. M. E. paper.

New Haven, Conn. H. D. Fisher.

The Human Element in the Power Plant

There is, in the technical press, a great deal of information available on methods of operation and "kinks" in handling equipment but it is seldom that one sees any "kinks" on handling that most important part of any organization, the man who does the work.

Picture the various plants you have worked in. Do you recall the engineer who took you in, showed you the coal pile and scoop and where the feed water control was located and after giving a few directions about water levels told you to keep it hot? With his warning in mind, you kept it hot but that is about all you did do. Is it any wonder that the labor turnover was large?

Have you gone into an engine room to work with a confirmed grouch? You soon get disgusted with the job.

I remember one incident where I was a week getting over the shock I received. I went into a large industrial boiler room where I was turned over to the foreman. I was first surprised to see a young man about my age. He shook hands and showed me a locker to keep my clothes, then he took me out and gave me a personal introduction to the crew. I have never yet seen a crew as loyal or as full of pep as the one in that plant. The plant was run down and in a deplorable state but we were getting results equal and sometimes better than many modern plants in that vicinity and our wages were not as high as those in some other plants around us. That foreman knew how to handle men, and was a strict disciplinarian, but he knew his work and cultivated that spirit of friendliness among his men that is so essential. Today he is occupying a private office and he had a man trained to fill his place when he left us to go on up.

I have always tried to imitate that foreman in handling men under my charge.

There are many courses offered in foremanship, how to rate the worker and all that but the best course to follow is to be human. Treat your men as you would like to be treated. Be firm; be fair and know your work and see that it is done. The failing of many engineers is that they are so wrapped up in the mechanical details of their positions that they fail to realize that the crew they build up will make a larger reputation than mechanical inventions. The company officials appreciate it as it costs nothing more than the use of a little kindness.

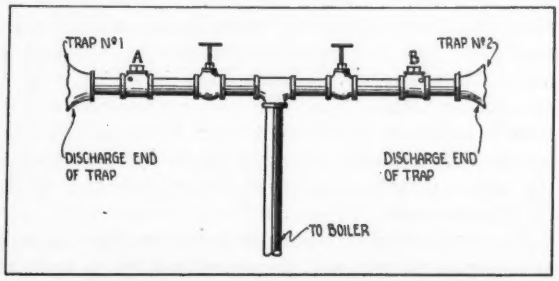
My idea of a good foreman is one who is firm and is fair, who does not listen to tales brought by one employe about another, who does not go to one employe to find out how his Buddy is getting along, and who is kind and always speaks in an even tone.

The next time you hire a new fireman or oiler, greet him with a smile, show him around, offer a few explanations and tell him something about the firm's business; in other words, get him to feel that he is a part of an organization that does things, then watch him grow.

New Kensington, Pa. JAMES H. COX.

Leaky Check Valves Cause Trouble

FREQUENTLY WE find that where two boiler feed traps discharge into one main pipe, as shown in the accompanying sketch, there are times both traps operate together to



LEAKY CHECK VALVE REDUCES CAPACITY

furnish sufficient water to the boiler. Often both traps are not able to furnish sufficient water for the boilers although they seem to be in first class operating condition where this trouble exists. It is a sure sign that one of the swing discharge check valves at the traps is leaking badly. This may be at either No. 1 or 2 trap as shown in the illustration at A and B.

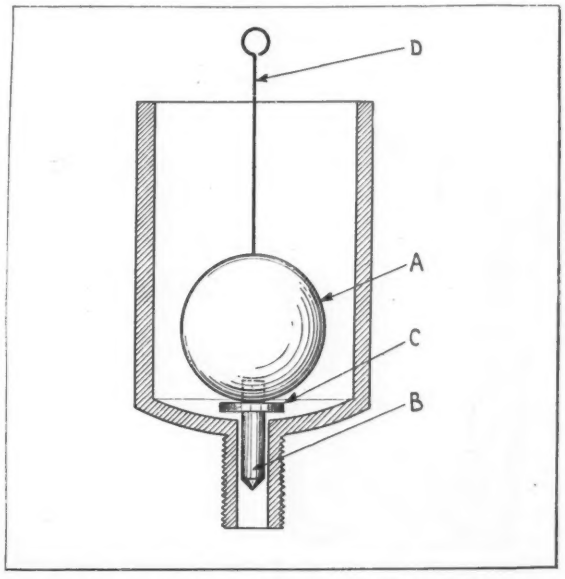
I had a case of this kind some time ago where two traps discharged into one main pipe. One day it was noticed that both traps were not able to furnish sufficient water to the boilers although in examining the traps nothing seemed to be wrong. In thinking the matter over I decided to examine both discharge check valves on the traps, when I found that one of them leaked badly. As the valves were of the renewable disc type, a new disc was placed. After this there was no further trouble.

When the trap with the leaky check discharged, the full amount of water in the trap tank would go into the boiler but when the trap with the tight check valve discharged and the one with the leaky valve was in the filling position, most of the water from the other trap would run into the tank of this trap through the leaky check valve.

Milwaukee, Wis. H. A. JAHNKE.

Easily Made Semi-Automatic Oiler

IN A mill where I was doing some work there was a large bearing which sometimes became overheated due to a defective oiler. The owner asked me to make up some



VIBRATION OF BALL ALLOWS OIL TO FEED SLOWLY

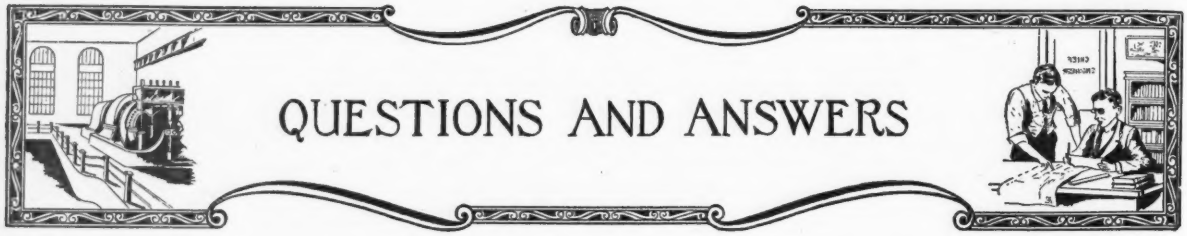
kind of an inexpensive oil feed arrangement that would remedy the condition.

I found an old 1-pt. oil cup and a steel ball. I drilled and tapped a hole in the ball for the ¼-in. pin, B, and the lifting wire, D, as shown in the accompanying sketch. The cup was inserted in the bearing oil hole and the leather washer shown was removed. The natural vibration of the shaft would move the ball off its seat in the bottom of the cup sufficiently to allow oil to feed slowly to the bearing.

When the shaft was idle, the leather washer was placed on the pin to insure oil tightness.

The total time required to make this little contrivance was about 30 min.; the cost 45 cents.

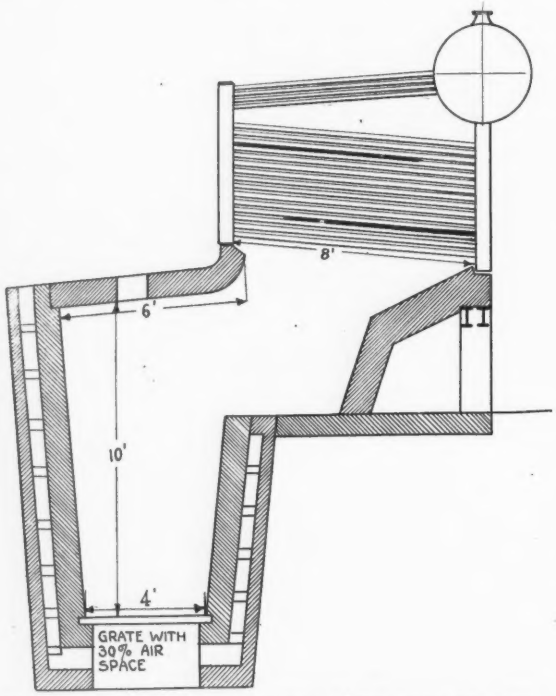
Toronto, Ont. JAMES E. NOBLE.



Would a Dutch Oven Help Efficiency?

IN THE June 1 issue on page 617, F. S. R. asks concerning the use of a dutch oven setting on a B. & W. marine type boiler for wood waste fuel.

My experience has indicated that the efficiency of these boilers is greatly improved by fitting a dutch oven to the furnace. The main difficulty has been to get sufficient volume in the furnace and to hold down the currents of air and gases so that they will not eat away the side walls too rapidly. In the accompanying sketch I have outlined a small arch about 6 ft. long, extending over the full width of the boiler, 11 ft. and furnace about 10 ft. high with grates of 4 by 11 ft. This gives a furnace volume of about 3 cu. ft. per rated horsepower. I have also indicated a hollow wall construction the purpose of which being to increase the life of the furnace walls and to pre-heat the air for combustion purposes. The principle that I have in mind is that the fuel will be dropped through the top of the furnace under the influence of gravity only, through at least two or preferably four holes. All the fine particles would be ignited and burned before reaching the grate. The walls have such a large amount of radiant surface that this is what I would expect to occur. The large pieces would probably fall clear to the grate and there build up in an open structure, which would enable the air to get to every part and make complete combustion possible. The radiant walls also would drive off the moisture rapidly. The small grate area would insure the grates being thoroughly covered so that cold currents of air would not pass through the furnace in zones and eat away the walls.



DUTCH OVEN SETTING THAT HAS GIVEN GOOD RESULTS

Best results in wood waste installations are obtained where the damper is controlled so that pressure within the furnace is no more than 0.1 in. water. It is always to be recommended that the fuel be hogged and that it be carried to the furnace openings by means of chains or screw conveyors so that it will be dropped into the furnace at a regular rate.

I have never seen this particular style of furnace installed for wood waste burning but observation of the regulation type of long dutch oven shows that they are inefficient. Nearly always the furnace is full of a pile of fuel and the burning is all on the surface. Also, in order to keep the grates covered it is necessary to fire a little coal in addition. Particles of charcoal lodge in the tubes and finally re-ignite, causing damage to uptakes and stacks.

Chicago, Ill. J. E. HARLOW.

Vacuum Pump Design

WE HAVE in our plant a 9 by 21-in. vacuum pump which we use for cleaning parts of our cotton carding machines. This pump is driven at 254 r.p.m. by a 35-hp. motor and maintains a vacuum of 28.5-in. of mercury. Experience has shown that we require only a 24-in. vacuum to do the work satisfactorily. How much power would I be able to save by running at 24 in.? Would it pay to install a smaller motor? At what speed should the pump run to maintain a 24-in. vacuum? G. I.

Is the Expansion Valve at Fault?

IN THE issue of Aug. 15, on page 873, A. M. Casberg makes the statement that it is a difficult matter to operate an ice plant in which part of the tanks are of the flooded accumulator type and part are not and that the tank is usually flooded sufficiently when there is a light coat of frost on the telltale pipe. He also recommends a temperature difference of not more than 6 deg. between the brine and the ammonia, carrying the back pressure about 1 lb. higher than the number of degrees indicated by the brine thermometer.

The great difficulty is not due to the two types of tanks but rather to the fact that the operator is trying to do all the work with one or two expansion valves while the rest of them remain partly closed or clogged up with small particles of dirt.

The telltale pipe will tell the same tale with only one expansion valve open as it will with a dozen. In this case the one valve will be considerably wider open than the others, the temperature of the brine will remain higher,

the back pressure will be low and the backfrost line will be easy to regulate with this one valve.

If the temperature of the brine is 15, and the ammonia 9 deg., the back pressure will be not less than 22 lb. To do this and yet carry the back pressure 1 lb. higher than the temperature reading is impossible, considering the 6-deg. difference between the ammonia and the brine.

Kansas City, Mo. J. M. HINES.

Heating Surface Required for Dry Kiln

F. S. R., IN THE Aug. 15 issue, inquires as to the additional amount of radiation required to bring the enamel kilns at his plant to a proper temperature.

The heat loss through the sides of the kiln may be expressed as

$$H = KA\ (t_1 - t)$$

Where A, is the total wall area of the kiln; k, the average coefficient of heat transmission; t_1, the average outside temperature; t, the average temperature in the kiln.

A is a constant and K may be considered so, for the small variation in temperature involved in this problem.

Let us first consider the kiln operating in the summer time with an average outside temperature of 80 deg. F. The heat loss is therefore

$$H = KA\ (147 - 80) \quad \text{or} \quad 67\ KA$$

To maintain a temperature of 160 deg. F in the kiln, however, the heat loss would be

$$H = KA\ (160 - 80) \quad \text{or} \quad 80\ KA$$

The ratio of the radiation required to that installed is therefore

$$80 \div 67 \quad \text{or} \quad 1.19$$

Considering next an average outside temperature of 50 deg. F., the heat loss with the present radiation is

$$H = KA\ (147 - 50) \quad \text{or} \quad 97\ KA$$

and with the kiln at 160 deg. and

$$H = KA\ (160 - 50) \quad \text{or} \quad 110\ KA$$

$110 \div 97 = 1.135$, ratio of required to installed radiation.

I would say to provide for the first case and either raise the steam pressure 14 lb. or bring the total radiation up to

$$1.19 \times 350 \text{ or say } 420 \text{ sq. ft.}$$

Chicago, Ill. R. J. PASK.

Piston Ring Clearance

ON PAGE 872 of the Aug. 15 issue, C. O. H. asks concerning the allowance for piston rings. For practical operation a ring should have a clearance sufficient to take care of the heat expansion but it must also be taken into account that foreign matter like baked oil or a burr can occur between the two ends and fill up some of the space. Some cast iron "grows" so to say in contact with superheated steam.

For a 32-in. ring, $\frac{1}{16}$ in. is not enough. Theoretically it would be .312 or $\frac{5}{16}$ in., but the ring never reaches the temperature of 150 deg. F. superheat (515 deg. F. total temperature). I would allow $\frac{3}{16}$ in. and use a step cut ring, the lap length equal to the width, with rounded corners made by drilling holes so they would not break too easily. I never use bevel-cut rings singly in a groove because as they wear they get worse.

It is possible that all the pounding mentioned is caused by the rings; the piston probably runs hot and the pounding may be felt also at the crosshead and connecting rod. Such a ring costs at least $10 and often it is worth making babbit lined rings. It is more work than a common one but many times is the only cure for the extreme wear and pounding.

Death Valley, Cal. CHAS. LABBE.

Measuring Boiler Blow-Down

IN THE July 15 issue, on page 772, G. W. G. asks for a method for measuring the quantity of blowoff from a boiler.

By making careful measurements of the length and cords at various water levels, a fair estimate can be made of the volume and weight blown down by simply noting the position of the water level in the gage glass. By making a series of these measurements the gage glass can be calibrated to show the weight of water in the boiler at various levels or the difference between any two levels.

In calibrating the gage glass, variations in the density of water at different temperatures should be taken into account. It is convenient to calibrate the glass at about ½-in. intervals.

Care should be taken that while blowing down, the feed pump should be stopped and the steam flow should be at a minimum.

Roughly speaking, blowing down 2 in. on a 66-in. by 18-ft. return tubular boiler with the water at the normal level, 4 in. above the upper row of tubes, will discharge about 1000 lb. of water.

Toronto, Ont. JAMES E. NOBLE.

Surface Required for Water Heater

I WISH to heat 1500 gal. of water per hour from 35 to 200 deg. F. with low pressure steam. What size pipe should be used for best results and how many feet will be required? Steam will be taken from a low pressure boiler at 5 lb. pressure. H. O. A.

A. The most economical method of heating water with steam where the steam is free from oil, is actually to mix the two. In this way, of course, it is possible to obtain a 100-per cent heat transfer.

To heat 1500 gal. or 12,500 lb. of water per hour from 35 to 200 deg. F. or through a range of 165 deg. F. requires $12{,}500 \times 165 = 2{,}060{,}000$ B.t.u. per hr. If the heating is done indirectly, through the medium of a steam coil, it would probably be necessary to discharge the condensate at a temperature of about 212 deg. F. At 5 lb. pressure the heat available from 1 lb. of steam condensing at 212 deg., is $1155 - 212 + 32 = 975$ B.t.u. The amount of steam required, then, to supply 2,060,000 B.t.u. per hr. would be $2{,}060{,}000 \div 975 = 2120$ lb. per hr.

The mean temperature of the water in being heated from 35 to 200 deg. is practically 117.5 deg. The steam temperature at 5 lb. gage pressure is 228 deg. F., consequently the mean temperature difference is $228 - 117.5 = 110.5$ deg. F. It may be safely assumed that the factor of heat transmission from the steam to the water through the tube, where there is no positive circulation, would be about 100 B.t.u. per sq. ft. of surface per deg. difference in temperature per hour. As the mean temperature difference is 110.5 deg., the heat transmission will amount to $110.5 \times 100 = 11{,}050$ B.t.u. per sq. ft. per hr. The amount of surface required may then be found to be $2{,}060{,}000 \div 11{,}050 = 187$ sq. ft. If 1½-in. pipe, which has about 2.01 feet length per sq. ft. of external surface, is used, $187 \times 2.01 = 375$ ft. will be required.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

The Mark of the Illiterate

Omar, the Persian tentmaker, gave utterance to deathless truths in his immortal "Rubaiyat." And while we may find it impossible to subscribe to all his philosophy there is one verse, we believe, that is acceptable to all:

"The moving finger writes: and having writ, moves on:
Nor all thy piety nor wit
Shall lure it back to cancel half a line,
Nor all thy tears wash out a word of it."

How fitting that is when one thinks in terms of votes. The American citizen, entering a curtained booth, takes pencil in hand and marks the names of the men on whom he hopes to rely for good government throughout the ensuing years. It is the one opportunity for the American to signify his choice of all those popularly chosen for leadership.

Voting is an American birthright, and it is our duty, as Americans, to take advantage of and exercise our birthright.

Have you decided upon your choice of men? Have you yet selected, from those available, him who in your judgment would best meet the requirements of chief executive? Far be it from us to influence you in your selection. Politics is outside the bourne of technical journalism. But mark well Omar's truth. Once signified, your choice is beyond recall.

Character is the first needed quality of a President of the United States. Brains and ability he needs too but more than those he needs character. The best brains and greatest ability are at his command. Leaders in every profession, however busy or great, will drop their personal matters to answer the call of the President and from this counsel almost any candidate could discover what was right as well as what was wise. But it takes moral stamina —character—to act on that knowledge. That is why character is paramount over all other requisites in Presidential timber. Only character can give a man the strength necessary to withstand misrepresentation, defection and disloyalty.

Mark well Omar's truth. Then mark well your ballot.

Business Is Good, Thank You!

According to the National Industrial Conference Board the tide of business is rising. Their conclusions are that the corner has been turned and that generally speaking, business is on the upgrade. To quote from their semi-annual report:

"During July, 1924, a considerable betterment in sentiment has taken place, for although production has not increased materially, inquiries in respect to orders are more numerous. Trade sources indicate that June marked the low point in business so far this year, and that the turning point has been reached. Exports for the first six months were 7.4 per cent greater in value than for the first six months of 1923."

The board points out that the index of production in basic commodities as compiled by the Federal Reserve Board for the first six months of 1924 shows an increase over the average index figures for any year since 1920. From 1920 to 1923 inclusive, the average was 94; for the first six months of 1924—111. The report also points out that unemployment is on the decline and that now it exists noticeably only in certain industries and in particular trades.

Last week we had occasion to look over about 160 different trade journals. After having gone through about a third of them we were struck with the similarity of statements of good business. We conceived the idea of jotting down the titles of some of the lead articles. Some of those we copied were: "Outlook for Business Encouraging," "Recent Gains in Trade Noted," "Eighteen Banks to Reopen," "General Trade Gain Presaged by Silk Rise," "Grain Prices Spell Prosperity," "Symposium Says Trade Looking Up," "Increased Number of Orders Characterized June," "Trend of Buying Upward," "Leathers and Textiles Show Gain," "Trade Shows Improvement," etc.

Yes, thank you, business is good.

A Lesson in Economics

If you own an expensive watch and take it to a skilled watchmaker to be repaired, whose watch is it after he has fixed it? Does it still belong to you or does it now belong to the man who worked on it by virtue of his labor?

To whom does the control of the watch belong? Does the man who worked upon it, by that labor, gain the right to decide whether he will hand it back when you have paid the bill, or can he sell it and divide the proceeds with you?

The worker has every right to a fair, even generous return for his labor. He has every right to reasonable hours and good working conditions. If methods of sanitation or operation are improved, if equipment is devised that will lift the burden of drudgery from his shoulders, he has every right to be accorded the benefits of those improvements. He has the right to offer his services for sale as well as to withhold such services. But certainly his labor gives him no right to control an industry since it gives him no title to ownership.

There is a well-directed movement on foot to throw the ownership or control of the railroads into the hands of the government. Since all of us are the "workers," regardless of our particular capacity, the workers of the United States form the government. Hence the movement would give control, if not direct ownership, of the railroads to the workers. If the answer to the second paragraph is "No" —how can the worker, by virtue of his labor, expect the title of ownership to the various transportation systems?

We need again a primary lesson in economics.

Storing Coal Without Danger of Spontaneons Combustion

When bituminous run-of-mine coal is stored in piles 30 ft. high and allowed to remain in storage for long periods of time, without the slightest danger of spontaneous combustion, the method of storage is worthy of note. This has been done repeatedly at the Chester, Pa., station of the Delaware County Electric Co.

A locomotive crane, equipped with a 1½-yd. grab bucket, stores the coal out in piles reaching upwards of 30 ft. In order to prevent internal heat or spontaneous combustion, the coal is delivered rather evenly over the piles in successive layers 3 or 4 ft. deep. Each layer is packed down with a heavy roller drawn by a crawler tread tractor. The roller seals each layer by its crushing or packing action, which prevents the entrance or circulation of air. Coal has been allowed to remain in storage in this manner, in quantities ranging upwards to 125,000 T., for 2 yr.—then found, upon reclamation, to be entirely free from internal heat.

1923 Wages in Thirteen Cities

Following is a tabulation of wages paid to various crafts, using London as a basis for calculation. Note America's standing in comparison with all other industrial cities.

Credit must be given to the British Ministry of Labor Gazette for this table.

INDEX NUMBERS OF COMPARATIVE REAL WAGES, 1923—(LONDON, 100)

	Mason	Bricklayer	Carpenter	Plumber	Painter (General)	Unskilled Laborer	Machinist	Ironmolder (Hand)	Pattern-maker
London	100	100	100	100	100	100	100	100	100
Amsterdam	107	107	107	116	122	118	108	96	101
Berlin	61	61	61	54	57	77	57	58	53
Brussels	70	70	76	64	65	67	73	78	95
Christiania	86	86	82	80	91	108	104	106	97
Madrid	50	50	56	52	55	50	83	78	78
New York	274	274	247	242	260	...	162	215	197
Ottawa	217	217	179	200	175	161	196	197	210
Paris	71	71	71	70	75	88	58	59	54
Prague	63	63	63	...	68	67	54	61	...
Stockholm	95	95	95	86	112	112	79	81	74
Vienna	57	57	60	...	65	61	62	...	...
Warsaw	79	79	...	...	83	84	61	62	57

Buy Your Coal Now

According to the U. S. Geological Survey, soft coal production of this year is far below that of 1923.

Up to the 30th of August, or in the first 206 working days of this year, only 294,629,000 tons of bituminous coal had been produced, compared with 366,349,000 tons in the same period a year ago.

Production for the week ending Aug. 30 totaled 8,733,000 tons which total was 3,004,000 tons under the same week in 1923.

The "Railway Age" believes the extremely slow coal movement and the depleted conditions of domestic and industrial coal reserves, coupled with public apathy toward the necessity for buying coal now, will work havoc to both coal and transportation companies when once cold weather has set in. An article in a recent issue of that publication says:

"The railways at present have about 170,000 coal cars in good condition rusting their wheels on side tracks because they are given no coal to haul, and industrial concerns and domestic consumers, with astounding lack of foresight, are persistently refusing to buy coal in normal quantities.

"The railways have demonstrated repeatedly that they can easily handle all the coal that is required if they are given a chance to handle it in a volume that is anywhere near uniform. They cannot haul it economically or satisfactorily when shipments fluctuate 50 to 75 per cent between different seasons. The huge seasonal shipments clog the transportation machine and when the machine becomes clogged, the demands for coal soon exceed the supply and abnormal prices result. Business concerns and domestic consumers in the long run pay for these vast fluctuations in coal shipments in unnecessarily high transportation costs and unnecessarily high coal prices."

If you haven't yet purchased your winter's supply of coal—buy it now.

Reduce Working Forces—Not Wages

Except for the radio, or the air service, neither of which yet justify the characterization of "industry," the automotive is our "infant" industry. That is, "infant" in point of years.

Though our youngest industry it is one of our huskiest, for it now ranks third or fourth among those going to make up commerce. In spite of its age, however, it has perhaps taught us more about production methods, the value of automatization, and general manufacturing procedure than any other industry.

Now, they come forward with another lesson which almost every phase of commerce may well example. This time the lesson does not appertain to the moving of materials or the automatizing of processes. Rather to the department of management.

The automotive industry has not been producing the large volume of cars they did during 1923. And in meeting this production slump they have learned that wages, in themselves, do not constitute a major part of manufacturing costs. They have proven for themselves that a decrease of 10 per cent in wages many times means less than 1 per cent in unit manufacturing cost. Learning this lesson they have cut working forces rather than wages.

On many occasions, wage reductions are necessary and justifiable. Sometimes the expense of labor turn-over is greater than the decreased efficiency resultant from wage reductions. As a general rule, however, the automotive industry employs a reduction of working forces rather than wage scales to accomplish their desired end of diminished overhead. Contrary to some other industries they take unit costs as a basis of analysis instead of that of gross expenses.

The definite and practical money-making value of contented and enthusiastic workmen has not yet been accorded the universal recognition it justifies.

TIME WAS when the Mediterranean Sea was the center of the earth. But the world moves apace and the center of commercial and military activity today is the Atlantic Ocean.

The time is coming when the Atlantic will be relatively as important to the Pacific and the world, as is the Mediterranean to the Atlantic.

BEING INTOLERANT means that you have broken your steering wheel and are stepping on the gas.

EDITORIAL COMMENT

Mathematical Formulas in Graphic Form

Why should a man do his work in the most difficult way possible when he has at hand a means that is sufficiently accurate, will save time and requires but little mental effort to use? We refer to mathematical calculations which should be a part of every man's daily task in the power plant but so frequently are never performed.

All mathematical calculations are made up of simple addition, subtraction, multiplication and division. Few men hesitate at any of these simple computations even though they do take considerable time and extreme care when done by ordinary arithmetic. It is the involved equation made up of several of these computations that frightens the average man into mathematical paralysis.

From the beginning of mathematical history men have endeavored to shorten calculations and, with this end in view, have devised the different branches of the science, such as algebra, geometry, trigonometry, graphic algebra, analytics and calculus, each of which is based on laws governing the relation of numbers and is applicable to the quick solution of specific problems. To use these methods to advantage, however, requires a well drilled, master mind.

Within the scope of the present generation, those who need to make calculations of a complicated order have been given more convenient aid in the form of charts which in fact are nothing more than measuring scales to be used in a specified order for the solution of a particular mathematical formula. With proper care in their design and construction they are as dependable as the slide rule which has come to be used with a confidence equal to that of the multiplication table.

Notwithstanding this, many engineers, not only those who are not mathematically inclined, but others who are adepts with the slide rule and familiar with the solutions of algebraic formulas of all kinds, pass up the aid available in the graphic calculating chart as being too complicated for them to understand or not sufficiently accurate for their purpose. There are of course good reasons for both of these objections but the men who hold such views usually magnify these faults to the point where they class all charts as impracticable.

These same men will, without a question or doubt, use the yard stick, protractor, micrometer, balances, spring scales, transit, pressure gages, flow meters, electric meters, planimeter and depend on their readings to the third or fourth figure and yet they would have extreme difficulty in checking up the accuracy of their instruments. To check a calculating chart requires only the working out of a few problems by long hand in addition to their solution on the chart.

Many bunglesome charts have been designed but the science is becoming simplified to the point that any person who can read a scale can use the chart with an accuracy equal to the data from which the calculations are made. With such an aid the daily calculation of heat balance and efficiencies becomes work of but a few seconds whereas the ordinary methods will not be used except on rare occasions when it is suspected that something is decidedly wrong.

Let's make our work as easy as possible consistent with the accuracy required, put our frequently used mathematical formulas into graphic form and save time in making daily calculations.

Thermodynamics Essential in Understanding New Practices

If you wish to secure a definite conception of the reasons behind the new developments in power plant practice such as regenerative feed water heating, reheating and high boiler pressures it is necessary to get out the thermodynamic textbooks and review the theoretical considerations which lie back of these developments. Practically the whole story of these latest attempts to raise power plant efficiency is built around a study of the Carnot and Clausius' cycles.

Ordinarily it is rather difficult to explain these principles in simple, easily understood language. Sir Charles Parsons, England's eminent turbine designer, has, however, covered these points so clearly and so concisely in a paper on Steam Turbines which he presented before the World Power Conference, that we wish to quote three pertinent paragraphs. In commenting on these phases of power plant development he stated that:

"Advance in the direction of increasing the thermodynamic value of the heat in the steam without unduly increasing the maximum temperature, is being made by increasing the mean temperature of heat reception. One method of effecting this is the adoption of regenerative feed water heating, by using steam tapped off from successive stages of the turbine. The necessity to heat the feed water, that is, to reheat the water of condensation is the defect of the Clausius' cycle. If, however, a perfectly regenerative process could be employed for heating the feed, the efficiency of the Clausius' cycle for saturated steam would be brought up to that of the Carnot cycle. In such a process the steam tapped off has been expanded, doing work in the turbine, down to the temperature at which it is required to heat the feed water. Since a certain amount of heat is required for this purpose in any case, the work obtained from the tapped off steam is obtained merely at the expense of additional heat equal to the work done, or, in other words, at 100 per cent efficiency. Expressed in another way the utilization of some of the heat of the steam to heat the feed water reduces the amount of heat lost by condensation in the condenser.

"As a second method of increasing the mean temperature of heat reception, an advance might be made, if, after

superheat to the maximum temperature, further heat might be added so as to maintain isothermal expansion throughout the initial stages of the turbine. This could only profitably be carried to such a point that subsequent adiabatic expansion in the turbine to the condenser vacuum would leave the steam just saturated. Such a method (of preliminary isothermal expansion) was proposed many years ago but the mechanical difficulties in the way to its complete realization would appear to be insurmountable. An approximate solution, however, is being worked out at the present time; in some installations the steam, after a certain amount of expansion in the turbine, is extracted and raised again to a high temperature in a re-heater before re-entering the turbine. Reheating has also the additional advantage of extending the range within which superheating exists and of diminishing the range where moisture and consequent loss by water resistance or increased viscosity exists.

"A third method of attacking the same problem is to increase the mean temperature of the heat reception by increasing the boiler pressure. With a boiler pressure of 250 lb., a final temperature of 750 deg. F. after superheating, and a feed water temperature of 79 deg. F., the mean temperature of heat reception is about 360 deg. F. But if the boiler pressure is increased to say, 2000 lb., still superheating to 750 deg. F., then since the latent heat is received at the increased temperature of the boiler, the mean temperature is considerably increased, namely to 480 deg. F. If, in addition, we assume the water is fed into the boiler at the boiling temperature by means of feed heaters, in cascade in each case, instead of at 79 deg. F., the mean temperature of heat reception is increased in the one case to 430 deg. F., and in the other to 680 deg. F."

Since fundamental principles are so essential in understanding these developments it will be well worth while to review the Carnot and Clausius' cycles where recollections are hazy as to just what these cycles mean. For those who have not had an opportunity to study thermodynamics it will be money well spent if an elementary book on the subject is secured.

Keeping Up with Instrument Progress

If the engineer had to depend only upon his senses for information relative to what goes on in the equipment under his charge, he would, indeed, be severely handicapped. His senses of vision, hearing and touch in spite of the marvelous organization behind their production would tell him practically nothing so far as quantitative values are concerned. In an effort to determine the temperature of the feed water, for instance, he might place his hand on the feed line, but beyond burning his hand if the pipe happened to be hot, that act would tell him nothing. To be sure, he would know whether the water was hot or cold but whether its temperature was 204 deg. or 220 deg. would remain a mystery to him.

To determine the temperature accurately he must use a thermometer. This device in spite of its mechanical simplicity is far more sensitive to temperature changes than one's hand and much more satisfactory from a physiological standpoint.

The same condition prevails for almost every other quantitative measurement made in the power plant. Whether it be in weighing a ton of coal, measuring the speed of a shaft, or determining the voltage of a generator, in each case the use of some instrument or meter is essential. Instruments and meters are the artificial eyes which enable the engineer to overcome his inherent blindness to the accurate perception of natural phenomena. Without them he is almost totally blind.

Consider the eye. This organ, with its wonderful power of visual perception, is one of the most important in our body, yet it is sadly lacking as a frequency indicator. On the entire scale of electromagnetic vibrations, which extend from some three hundred million, billion cycles per second to about 20 cycles per sec. the eye is capable of detecting less than one octave on this enormous scale. In other words, the eye detects only those vibrations which we term visible light waves, and which vary in length between 39 and 76 millionths of a centimeter. If we wish to detect waves outside of these wave-lengths, we must resort to the use of frequency meters, radio receivers, fluorescent screens and photographic plates. With these instruments we augment the power of the eye a thousand fold.

Similarly, in a thousand and one ways, instruments of various types extend the power of the engineer in the plant. A knowledge of instruments and their application is therefore of vital importance.

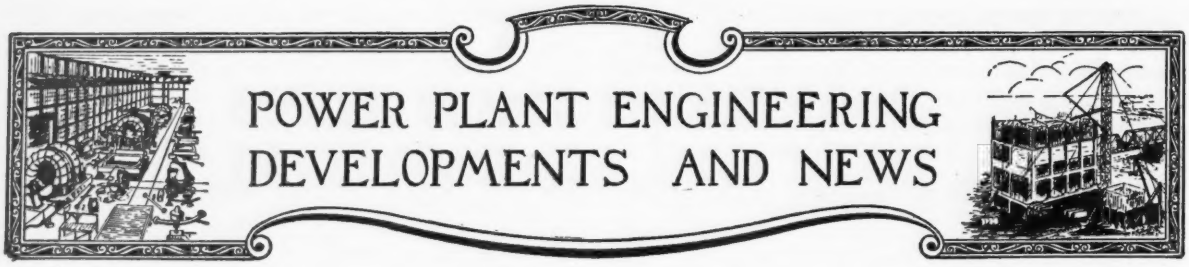
To this end, every engineer should make it a habit to acquaint himself with developments in the instrument field so that he may avail himself of such new instruments as will be of use to him. A knowledge of what may be accomplished by the use of certain instruments may often clear up mysterious causes of trouble.

A case in point is the portable oscillograph developed within the past few years. To most technical men the word oscillograph is suggestive of the laboratory—something not adaptable to every day use in the plant. And until the portable oscillograph was perfected, this was correct; the oscillograph was purely a scientific instrument used in the laboratory only. In the portable oscillograph, however, we have a fairly rugged instrument which has a number of extremely useful applications in the electric power plant.

In the operation of transformers, for instance, certain mysterious cases of heating were, when subjected to oscillographic tests, found to be due to the circulating third harmonic current in the transformer bank. In the paralleling of alternators, the portable oscillograph finds application in determining the wave forms of the machines and thus predict their performance when operating in parallel.

Now, it is not the purpose of this editorial to suggest that every engineer buy a portable oscillograph, indeed, if anything it would be the contrary, for only one plant in a hundred might have sufficient use for it to warrant its purchase. The thing which we wish to point out, however, is that such an instrument exists and that at times it may prove extremely useful. At such times, any progressive engineer will no doubt be able to obtain the use of one for purposes of testing.

Similarly, a knowledge of other instruments may help him out of other difficulties. The mere knowledge of the means of diagnosis is half the battle won in running down any case of trouble.



Technical Program Featured by N. A. S. E.

SUCCESSFUL EXHIBIT AND TECHNICAL DISCUSSIONS MARKS 42ND ANNUAL CONVENTION AT GRAND RAPIDS

ENTHUSIASM and success marked every phase of the N. A. S. E. convention which took place at Grand Rapids, Michigan, during the week of September 8. This was evidenced by the great number of excellently appointed booths at the power plant equipment exhibition and in the interest which was displayed by the members of the associations both in the equipment display and in the transaction of association business. One feature of particular interest to all of those in attendance was the program which had been prepared by the Technical Paper's Committee. This program was extremely broad in its scope and covered many of the most vital problems with which engineers are confronted today.

Labor and horsepower, both here and abroad was the subject presented by Chas. M. Ripley, electrical engineer. This paper was based upon personal observation and study and it disclosed that American enterprise has harnessed the powers of electricity and steam to produce the comforts of life and its necessities in great abundance and in this respect American achievements are in marked contrast to the lack of development in Europe.

As a result of American utilization of power the people as a whole draw the benefit of higher wages and a larger abundance of the commodities of life which make for a higher and a better standard of living.

In Europe, Mr. Ripley says, it is not uncommon to see men taking the place of dray horses or huge canal boats are slowly and laboriously moved for comparatively long distances by men operating huge oars. In contrast to America, where that kind of work is performed by mechanical power, it gives some phases of Europe's industrial development the aspect of the slave labor which was used to construct the pyramids or which manned the Roman galleys.

By using mechanical and electrical power in as great a degree as possible we have succeeded in raising the labor of man to a higher level, we have made him more productive and given him greater privileges.

WATER POWER DEVELOPMENT WILL NOT ELIMINATE FUEL SUPPLY PROBLEM

With regard to the application and use of water power in America, Mr. Ripley quoted Steinmetz, with whom he was an intimate associate for a number of years. "If America were to use every drop of water within its boundaries not excepting water for drinking, household use or sanitary purposes, it could not develop horsepower beyond that which is required for the uses to which it is put at the present time." This emphasizes more than ever the urgency of fuel economy.

Following this talk several interesting motion picture reels were projected on the screen showing the manufacture of small household utility motors and the manufacture of the modern X-ray tube. Views were also in-

cluded showing wrist, elbow, knee, and foot bone motions as made possible by the X-ray.

Two score years of power development was the subject upon which Fred R. Low, president of the A. S. M. E. spoke. This talk covered a review of the many wonderful advances which have been made during the lifetime of the N. A. S. E.

Another paper which created widespread interest was that on the subject, The Application of Powdered Fuel in the Newest Power Plants by Frederick A. Scheffler, manager power department, Fuller-Lehigh Co. This paper stated that the velocity of gas through the furnace setting could safely be figured at 7 to 10 ft. per sec. and that with this range in velocity no excessive erosion of first grade brick work would occur. It was also stated that a furnace volume of 2 cu. ft. per rated b.hp. would permit taking short peak loads and indications are that by using a special firebrick, the furnace volumes of the near future can be reduced to about 75 per cent of that employed in present practice.

This paper was concluded by an illustrated talk on the new powdered fuel installation which has recently been made at the Trenton Channel plant of the Detroit Edison Co.

Three Papers Presented by Title

Three papers were read by name only, this being due to the absence of the authors because of the pressure of personal business. These papers were: Automatic Combustion Control Systems, by Charles H. Smoot of the Smoot Engineering Corp. Operation of Large Unit Boilers at High Ratings, by Dr. Edgar Kidwell of the Kidwell Boiler Co. Recent Developments in Ice and Refrigerating Plants, by Halbert P. Hill, Cons. Eng. This last paper appears as an abstract on other pages of this issue.

The electrical side of power plant work was presented by Val A. Fynn, Cons. Eng., who gave an illustrated talk on the Fynn motor which will operate as a synchronous motor at any load up to 150 per cent of rating, above which it will automatically change to operate as a straight induction motor: with a reduction of load it will again automatically return to synchronous operation.

Two papers were read on the subject of the Diesel engine as a power unit. The first was that by Lacey H. Morrison in which he pointed out that in any plant small economies might be made by close attention to supplies, water, lubricating oil and like incidentals, but the main hope for a substantial reduction in the cost of power generation lies in the fuel and labor items. The attention of power plant designers is centered upon these two items and as a consequence each new plant calls for larger and more economical prime movers, both turbines and boilers.

Surveys show that the fuel consumption of the small steam plant cannot be made to equal the records made by the large plants. It is for this reason that the engineer should be interested in the oil engine since this type of prime mover does hold the offer for relief from the excessive production costs of labor and fuel.

Advantages of Oil Engines Pointed Out

Special advantages which were pointed out for the Diesel engine were as follows: It shows practically the same fuel consumption regardless of its size; the Diesel engine operates efficiently over its entire load range; unlike most prime movers the oil engine has a sustained efficiency during its life; and, a careful investigation of the oil engine will show that except in those industries where a large amount of process steam is required, the Diesel engine will produce power at a cost equal to or less than the cost in the large central stations.

Diesel Engine Power Plants was the second oil engine paper of this session. This paper was presented by Louis R. Ford, of the Morse Dry Dock and Repair Co. This paper, an abstract of which appears in this issue, discusses the designs, construction and operation of the Diesel engine.

Two papers were presented which dealt with boiler room instruments. One was prepared by E. G. Bailey, of the Bailey Meter Co., who called attention to the fact that there has been an increase in the percentage of the total heat in coal lost through the condenser; this condition having been brought about by better boiler room efficiency. The present tendency, however, towards stage reheating will bring about a further change in this figure, lowering it so that the boiler plant will have to look for

Exhibitors at N. A. S. E. Convention

The Louis Allis Co. ..... Milwaukee, Wis.
Aetna Abrasive Co. ..... Chicago Ill.
Kenneth Anderson Co. ..... Detroit, Mich.
W. M. Ackerman Electric Co. ..... Grand Rapids
Allington & Curtis Mfg. Co. ..... New York, N. Y.
Allis-Chalmers Mfg. Co. ..... Milwaukee, Wis.
American Steam Pump Co. ..... Battle Creek, Mich.
Anchor Packing Co. ..... Philadelphia, Pa.
V. D. Anderson Co. ..... Cleveland, Ohio
Armstrong Machine Works ..... Three Rivers, Mich.
Arrow Boiler Compound Co. ..... St. Louis, Mo.
The Ashton Valve Co. ..... E. Cambridge, Mass.
Bailey Meter Co. ..... Cleveland, Ohio
Budd Grate Co. ..... Philadelphia, Pa.
Barclay Ayers & Bertsch Co. ..... Grand Rapids
The Bennett Injector Co. ..... Muskegon, Mich.
The Bigelow Arch Co. ..... Detroit, Mich.
Birch Mfg. Co. ..... Chicago, Ill.
Bousman Mfg. Co. ..... Grand Rapids, Mich.
S. F. Bowser & Co., Inc. ..... Fort Wayne, Ind.
Brooks Oil Co. ..... Cleveland, Ohio
Bussman Mfg. Co. ..... St. Louis, Mo.
Chicago Faucet Co. ..... Chicago, Ill.
Chicago Fuse Mfg. Co. ..... Chicago, Ill.
Chicago Metallic Packing Co. ..... Chicago, Ill.
Jas. Clark, Jr., Electric Co. ..... Louisville, Ky.
Clipper Belt Lacer Co. ..... Grand Rapids
Combustion Engineering Corp. ..... Detroit, Mich.
D. Connelly Boiler Co. ..... Cleveland, Ohio
Consumers Power Co. ..... Grand Rapids
Coon-DeVisser Co. ..... Detroit, Mich.
Crandall Packing Co. ..... Palmyra, N. Y.
Crane Co. ..... Chicago, Ill.
Dean Brothers Co. ..... Indianapolis, Ind.
Dearborn Chemical Co. ..... Chicago, Ill.
De Laval Steam Turbine Co. ..... Chicago, Ill.
M. H. Detrick Co. ..... Chicago, Ill.
Detroit Stoker Co. ..... Detroit, Mich.
Diamond Power Specialty Corp. ..... Detroit, Mich.
Joseph Dixon Crucible Co. ..... Jersey City, N. J.
Durametallic Corp. ..... Kalamazoo, Mich.
Economy Fuse & Mfg. Co. ..... Chicago, Ill.
Elliott Co. ..... Jeannette, Pa.
The Lagonda Mfg. Co. ..... Springfield, Ohio
(Liberty Mfg. Co. ..... Pittsburgh, Pa.)
Everlasting Valve Co. ..... Jersey City, N. J.
The Fisher Governor Co. ..... Marshalltown, Iowa
Flexible Steel Lacing Co. ..... Chicago, Ill.
J. B. Ford Co. ..... Wyandotte, Mich.
France Packing Co. ..... Tacony, Phila, Pa.
Foster Engineering Co. ..... Newark,N. J.
Great Lakes Valve Corp. ..... Chicago, Ill.
Great Western Oil Co. ..... Grand Rapids
Greene, Tweed & Co. ..... New York City
Gallmeyer & Livingston Co. ..... Grand Rapids
The Garlock Packing Co. ..... Palmyra, N. Y.
Garratt-Callahan Co. ..... Chicago, Ill.
Gifford Wood Co. ..... Albany, N. Y.
Globe Kneadable Metallic Packing Co. ..... Brooklyn, N. Y.
Grand Rapids Belting Co. ..... Grand Rapids
Grand Rapids Blow Pipe & Dust Arrestor Co. ..... Grand Rapids
Grand Rapids Boiler Works ..... Grand Rapids
Grand Rapids Spring Service Co. ..... Grand Rapids
Hawk-Eye Compound Co. ..... Blue Island, Ill.
Hayden Supply Co. ..... Grand Rapids
Heat Sealing Kant Burn Co. ..... Chicago, Ill.
Heine Boiler Co. ..... Chicago, Ill.
The Hill Pump Valve Co. ..... Chicago, Ill.
Hoffman Specialty Co. ..... New York, N. Y.
A. L. Holcomb & Co. ..... Grand Rapids
The Hollow Center Packing Co. ..... Cleveland, Ohio
Home Rubber Co. ..... Trenton, N. J.
Hooven, Owens, Rentschler Co. ..... Hamilton, Ohio
Howell, Electric Motor Co. ..... Howell, Mich.
Imperial Furniture Co. ..... Grand Rapids
Independent Pneumatic Tool Co. ..... Chicago, Ill.
Industrial Power ..... Chicago, Ill.
International Correspondence School ..... Scranton, Pa.
Jenkins Bros. ..... New York, N. Y.
Johns-Manville, Inc. ..... Cleveland, Ohio
Johns-Pratt Co. ..... Hartford, Conn.
Jointless Fire Brick Co. ..... Chicago, Ill.
Kelly Sales Co. ..... Detroit, Mich.
Kelley Valve Co. ..... Muskegon, Mich.
Kellogg Burlingame Co. ..... Grand Rapids
Keystone Lubricating Co. ..... Philadelphia, Pa.
King Refractories Co., Inc. ..... Buffalo, N. Y.
A. B. Knowlson Co. ..... Grand Rapids
The George T. Ladd Co. ..... Pittsburgh, Pa.
Leitelt Iron Works ..... Grand Rapids
A. Leschen & Sons Rope Co. ..... St. Louis, Mo.
Lewis Electric Co. ..... Grand Rapids
Liptak Fire Brick Co. ..... Chicago, Ill.
C. J. Litscher Electric Co. ..... Grand Rapids
The Lunkenheimer Co. ..... Cincinnati, Ohio
Manning, Maxwell & Moore, Inc. ..... New York, N. Y.
The Mason Regulator Co. ..... Dorchester Center, Boston, Mass.
McCullough Mfg. Co. ..... Minneapolis, Minn.
McLeod & Henry Co. ..... Troy, N. Y.
McMullen Machinery Co ..... Grand Rapids
Metzgar Company, Inc. ..... Grand Rapids
Michigan Boiler & Iron Works ..... Grand Rapids
Morehead Mfg. Co. ..... Detroit, Mich.
Multiplex Packing & Rubber Co. ..... Toledo, Ohio
National Engineer ..... Chicago, Ill.
National Tube Co. ..... Pittsburgh, Pa.
Nordberg Mfg. Co. ..... Milwaukee, Wis.
Wm. W. Nugent & Co. ..... Chicago, Ill.
Oliver Machinery Co. ..... Grand Rapids
Otis Elevator Co. ..... New York, N. Y.
The Permutit Co. ..... New York, N. Y.
The Perolin Co. of America ..... Chicago, Ill.
Phoenix Sprinkler & Heating Co. ..... Grand Rapids
Pioneer Rubber Mills ..... New York City
C. O. Porter Machinery Co ..... Grand Rapids
The Wm. Powell Co. ..... Cincinnati, Ohio
Power ..... New York, N. Y.
Power Plant Efficiency Co. ..... Indianapolis, Ind.
Power Plant Engineering ..... Chicago, Ill.
Quaker City Rubber Co. ..... Philadelphia, Pa.
Quigley Furnace Specialties Co., Inc. ..... New York, N. Y.
Reliance Gauge Column Co. ..... Cleveland, Ohio
Republic Flow Meters Co. ..... Chicago, Ill.
Richards Mfg. Co. ..... Grand Rapids
Richards-Nicklin Co. ..... Detroit, Mich.
Richardson Scale Co. ..... Chicago, Ill.
Ridgway Dynamo & Engine Co. ..... Grand Rapids
Sanford Riley Stoker Co. ..... Worcester, Mass.
John A. Roebling's Sons Co. ..... Chicago, Ill.
The Roto Co. ..... Hartford, Conn.
Scott Valve Mfg. Co. ..... Detroit, Mich.
Shallcross Control System Co. ..... Milwaukee, Wis.
L. S. Shaw & Co. ..... Grand Rapids
F. A. Simonds ..... Grand Rapids
Sinclair Refining Co. ..... Detroit, Mich.
Sinterbas Mfg. Co. ..... Cleveland, Ohio
Sloan Valve Co. ..... Chicago, Ill.
Southern Engineer ..... Atlanta, Ga.
C. E. Squires Co. ..... Cleveland, Ohio
Standard Oil Co ..... Grand Rapids
Standard Sanitary Mfg. Co. ..... Grand Rapids
The Superheater Co. ..... New York, N. Y.
The Texas Company ..... New York, N. Y.
Trill Indicator Co. ..... Corry, Pa.
Triplex ..... Grand Rapids, Mich.
Union Iron Works ..... Erie, Pa.
Union Steam Pump Co. ..... Battle Creek, Mich.
United States Rubber Co. ..... Detroit, Mich.
Universal Coal Spreader Co. ..... Chicago, Ill.
Vacuum Oil Co. ..... Chicago, Ill.
Viscosity Oil Co. ..... Chicago, Ill.
The Vulcan Soot Cleaner Co. ..... Du Bois, Pa.
Wayne Water Softener Co. ..... Detroit, Mich.
Wagner Electric Corp. ..... Chicago, Ill.
Warren Webster & Co. ..... Camden, N. J.
Western Electric Co. ..... Grand Rapids
Westinghouse Electric & Mfg. Co. ..... E. Pittsburgh, Pa.
Wickes Boiler Co. ..... Saginaw, Mich.
John Widdicomb Co. ..... Grand Rapids
The D. T. Williams Valve Co. ..... Cincinnati, Ohio
Wood Conversion Co. ..... Cloquet, Minn.
Wright Austin Co. ..... Detroit, Mich.
"X" Laboratories ..... New York, N. Y.
Yarnall-Waring Company ..... Philadelphia, Pa.

its efficiency elsewhere than heating feed water in an economizer. Mr. Bailey's paper pointed out further that instruments are used with large boiler installations not alone from the efficiency standpoint but also from that of safety of operation.

The second paper on instruments was a discussion of the development, application and installation of electrically operated flow meters by J. M. Spitzglass of the Republic Flow Meters Co. This paper carries the history through from the first experiments and also gives much valuable information upon installation.

Convention Opens Officially on Tuesday

Officially, the 42nd Annual Convention of the N. A. S. E. was called to order at 9:45 a. m., Sept. 9 in the convention hall of the Klingman Building. Chairman George J. Bulliss of the local convention committee presided at the opening ceremonies and welcomed the delegates and visitors to the city.

Mayor Swarthout, of Grand Rapids, was then introduced by the chairman. He gave the engineer due credit for his large share in the industrial development of Grand Rapids and vicinity. Following the Mayor's speech was a talk by Dean George W. Bissell of the Michigan Agricultural College. His remarks were confined to an historical sketch of steam engineering and the necessity for specialized education in modern industrial development.

Pres. Royal H. Holbrook of the N. A. S. E. then addressed the convention and following him was Past National President Felderman who called attention to the fact that that contact with our fellow men is one of the essentials of a successful life and that the dissemination of practical information was also a vital consideration.

Tuesday afternoon was the occasion of the national president's report. He reviewed the engineering achievements of the past year. Among these was the Mercury boiler at Hartford, Conn., the large steam turbines at Providence, Pittsburgh and at Detroit. Of special note was the announcement from England of the operation of boilers at a pressure of 3200 lb. per sq. in.

Turning from the field of steam power he directed the attention of his listeners to the great oil engines and mammoth water wheels which have been constructed during the past year. It was also pointed out that in America we have a cold storage capacity of 600,000,000 cu. ft. while in Great Britain they have but 38,000,000 cu. ft.

Regarding our fuel resources it was told that it is estimated that we have today 1,560,000,000,000 T. of coal in the ground of which 18 per cent is lignite, 29 per cent is sub-bituminous, 51 per cent bituminous and 2 per cent anthracite. In addition to this coal there is also 1,045,000,000 barrels of crude oil still available underground.

It was also brought out that a few years ago a fuel consumption of 10 lb. of coal to generate a kilowatt hour was considered good. Now such a figure as that is waste —an awful waste. The modern plant now gets a record of 1.78 to 2.28 lb. of coal for the same amount of energy.

Attention was also called to the work of the A. S. M. E. boiler code committee which has now been at work for about 16 yr. That committee has worked diligently and faithfully to perfect the present set of rules and instructions for the building of pressure vessels.

Following the president's address was the report of the National Deputy who emphasized the fact that in view of the more or less unsettled business condition throughout the country that the progress of the association has been exceptionally good. He also stated that a general survey of conditions indicated that in 1925 the association would be more successful than it had been in 1924.

Reports which then followed were those of the national secretary, the national treasurer, the technical papers committee and the ways and means committee.

At the Wednesday session, at which time there were reported 335 registered delegates, there were reports of the membership extension committee, the committee on constitution and the annual convention of the life and accident department. This session also gave time to the report of the power plant cost committee. This report stated that many plants do not keep adequate records and that the boiler rooms are sadly neglected in most isolated plants. An example was given of a well operated plant and recommendations were made so that this committee could carry on its work by its being made a permanent national affair.

That evening was given over to the exhibitors entertainment. This feature of the convention drew a large and enthusiastic audience of delegates and their friends. The program which was under the direction of Chairman Paul T. Payne, was as follows:

Piano—Courtesy of the Dearborn Chemical Co.

Geo. D. B. Van Tassel—Courtesy of the Bigelow Arch Co.

The Harmer Sisters—Courtesy of the Hollow Center Packing Co.

Pupils of Daddy Green—Courtesy of Home Rubber Co.

Geo. Ogden—Courtesy of the Squires Co.

Wolverine Four—Courtesy of Jointless Fire Brick Co.

Bobby Jones—Courtesy of the Garratt-Callahan Co.

Joe McKenna—Courtesy of Jenkins Bros.

B. J. Hogan—Courtesy of the Lunkenheimer Co.

At the end of the above entertainment the Milwaukee Engineers Visiting Club Band gave several selections.

Friday was the closing day of the convention and as has been the case in years past, it was the day upon which officers for the ensuing year were elected. The election of officers this year was practically without contest but one ballot having been taken for the election to each office. The officers for the ensuing year are as follows: Dudley G. Kimball of Boston, Mass., president; Garrett Burgess of Detroit, Mich., vice-president; Fred W. Raven of Chicago, Ill., secretary; Samuel B. Forse of Pittsburgh, Pa., treasurer; Henry Mistele of Milwaukee, Wis., trustee for 5 yr.; James S. Heath of Hoboken, N. J., conductor and C. A. Dobson of Knoxville, Tenn., doorkeeper.

Officers for the National Exhibitors Association were elected as follows: President, W. P. Lyons of Johns-Manville, Inc., Chicago, Ill.; vice-president, Chas. F. Green of the Home Rubber Co., Trenton, N. J.; treasurer, Geo. R. Rowland of the Texas Co., New York. Executive committee: W. L. Schaeffer of National Tube Co., Pittsburgh, Pa.; J. I. S. Pieters of Jointless Fire Brick Co., Chicago, Ill.; Jacob Eige of the Fisher Governor Co., Marshalltown, Iowa; W. L. Rogers of Pioneer Rubber Mills, New York City and W. T. Birch of the Birch Mfg. Co., Chicago, Ill. The officers and executive committee reappointed F. N. Chapman of the A. Leschen & Son's Rope Co., St. Louis, Mo., as secretary for the coming year.

The convention next year will be held at St. Paul, Minnesota.

Shockless Operation Is Feature of Pendulum Actuated Valve

HERETOFORE when a valve has functioned by the dropping of a weight, it has been necessary to place a stop to catch the weight before the working parts of the valve came in contact with the valve body, in order to be certain that the valve body would not be fractured by the impact. In a shockless type of valve recently brought out by the Everlasting Valve Co., of Jersey City, N. J., the pendulum so meshes with the gears that after the moving parts have been brought to the desired position, either open or closed, the weight and lever are relieved from any action against the internal parts and swing free as does the pendulum of a clock until the weight comes

VALVE IN OPEN POSITION SHOWING ARRANGEMENT WHICH PERMITS PENDULUM TO SWING FREELY

to rest. This removes any possibility of shock to the casing of the valve.

Valves of this type are built in either the closing or opening types. In the closing type the weight is carried by a single lever. The greatest resistance in this closing type is encountered just as the disc is making the final passage over the port. By the time this point is reached, the weight has acquired sufficient momentum to full close the valve. In the opening type the valve stands closed with the pressure against the disc. The greatest force is required at the moment when the valve is about to open. In this type, therefore, the weight is suspended on a lever which swings free from the functioning mechanism of the valve. When the release is broken, there is no resistance offered to the weight. It falls quickly and hits the functioning lever a blow. That blow overcomes the resistance of the disc at the cracking point of the valve and the weight then rests against the lower lever and carries the valve to the full open position.

Various tripping mechanisms may be used such as fusible links, floats or electrically actuated types. Valves of the closing type are for such service as emergency diverting valves, emergency shut-off for inflammable fluids and similar uses. Opening type valves may be used on sprinkler systems, foam systems, electric generator protection and similar services.

RED WING PRESERVING CO. of Fredonia, N. Y. have just installed one new 500-hp. Erie City vertical boiler, making the total boiler horsepower 1000.

Three New Plants Nearing Completion at St. Paul

WITH the completion within the next few months of two new steam stations and a new hydroelectric plant, St. Paul, Minn., will take its place as an important power center of the northwest. The three big developments are the plants of the Northern States Power Co., the St. Paul Gas Light Co. and the Ford Motor Co.

Up to the time the first unit of the Northern States Power Co.'s new High Bridge station was put in operation recently, there was only about 20,000 kw. of central station capacity in the city. This was not enough to handle the requirements so it was necessary to depend on power from outside sources. This capacity will be increased more than five times by close of this year with the addition of over 100,000 kw.

It is expected that the second 30,000-kw. unit at the High Bridge plant will be in operation about October 1. This will give a plant capacity of 60,000 kw. which will be further increased as the demands require. The Northern States Power Co. is one of the properties of the Byllesby Engineering and Management Corporation and the High Bridge Plant has been designed by the engineers of the Byllesby organization.

Another equally important development is that of the St. Paul Gas Light Co. This is to be a pulverized fuel fired plant built on an island about a quarter of a mile above the High Bridge. The first turbo-generator of 25,000-kw. capacity is now being installed, and it is expected that the plant will be in operation before the first of the year. Present plans call for the installation of an additional 35,000-kw. unit as soon as the work on the first unit is completed. Toltz, King & Day, Inc., consulting engineers of St. Paul are the designers of this plant.

In addition to these two steam plant developments the Ford Motor Co. is building a hydro-electric plant at the High dam on the Mississippi River. The plant, which is now nearing completion, is made up of four 4500-kw. units. The conditions of the permit granted by the Federal Power Commission call for the sale of surplus power to the Northern States Power Co. The Ford organization is also building a steam plant, designed for a maximum capacity of 10,000 kw. which will be used as a stand-by for the water power plant. Stone & Webster, Inc., of Boston are the designers of the hydro-electric plant.

When these various plants are completed St. Paul will take its place as a center of distribution to outside territories instead of being dependent on outside power for its industrial development.

Philadelphia Electric Co. to Use Conowingo Falls Power

PLANS FOR FINANCING the big hydro-electric development on the Maryland side of the Susquehanna River at Conowingo Falls have been completed. Development will be carried out by the Susquehanna Power Co., which has been taken over by the Philadelphia Electric Co. Financial details were handled by Drexel & Co.

Construction is expected to begin shortly. Plans call for a concrete dam 3300 ft. long with average head 62 ft. above bed of the river, and a power house 120 ft. wide and 700 ft. long. Eventually 10 turbines of 30,000 hp. each

will be installed, but the initial installation will be 6 turbines, with 180,000 hp. Expenditure at the outset is estimated at $15,000,000, and $30,000,000 when maximum capacity is developed.

Part of the preliminary work will be raising 20 mi. of the roadbed of the Columbia & Port Deposit Railroad, a branch of the Pennsylvania Railroad.

All rights of way along the river have been acquired, and most of the strips of land for the transmission line from Conowingo to Philadelphia have been bought. All current will be distributed by the Philadelphia Electric Co.

Power Show to be Held in New York, Dec. 1 to 6

OVER 260 exhibitors have been assigned space at the Third National Exposition of Power and Mechanical Engineering which will be held in the Grand Central Palace, New York City, from Dec. 1 through Dec. 6. As this number is more than two times greater than those who had engaged space on August first a year ago, the indications are that the coming event will be of tremendous interest and importance. The 1923 Exposition drew an attendance of 62,079 engineers, executives, financiers, operating men, as well as large numbers of engineering students with their instructors. This is an increase of 15,000 over the number who attended the 1922 Exposition.

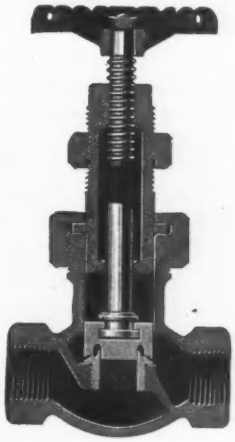
As the expressions of appreciation and interest in the 1923 exhibit were proof of the value of the Exposition and as the large attendance of vitally interested visitors was a great satisfaction to those exhibiting, it is safe to assume that the coming event will greatly surpass all of its predecessors. The constant growth of the Exposition is interesting proof that the industries related to power and mechanical engineering are in a state of rapid development, and need the inspiration and ideas started at the Exposition. The growth of the Exposition has also been an object lesson to these industries, for in addition to giving the engineering and general public an idea of the size and importance of the industries, it has dignified the industries in the eyes of those engaged in them and presented a perspective of functions and methods that nothing else could have provided.

As usual, the Exposition will parallel the meetings of The American Society of Mechanical Engineers and the American Society of Refrigerating Engineers. The A. S. M. E. meeting will be held in the Engineering Societies Building, 29 West 39th St., New York City, and the A. S. R. E. meeting will be held at the Hotel Astor, New York City. Plans are under way for the American Society of Heating and Ventilating Engineers to have a gathering of Local Sections during the time of the Exposition. The co-operation of the various engineering societies has been valuable, since it enables members to attend the meetings and at the same time see the exhibits.

ATTENTION HAS been called to the fact that, in the description of the method of pouring baffles around paper tube thimbles, published on page 925 of the September 1 issue, no mention was made of patents being held on this process by the Heine Boiler Co. In order to use this process, therefore, it will be necessary to secure the permission of the owner of the patents.

Bronze Stop Valve Built with O. S. & Y. Bonnet

IN ORDER to build a stop valve in which the stem threads are not exposed to the action of high temperatures and destructive fluids which might break down the metal of the inside screw type, the Edwards Valve & Manufacturing Co., of East Chicago, Ind., has recently developed a valve with an outside screw and yoke bonnet. The bonnet is of forged Tobin bronze. In order to provide ventilation for the stem threads the bonnet is slotted. This part of the construction does not show in the sectional view as these slots are at the front and back as will be noted from the accompanying illustration a packing box of ample size has been provided. The packing nut is of monel metal and the design permits packing the valve while under pressure. The body is of hard steam bronze and the seat and



STEM THREADS ARE VENTILATED BY SLOTS IN YOKE

disc are monel metal of the regular Edwards protected type construction. In this valve the stem is of rolled monel metal with long threads engaging the bonnet and with a bronze plate at the end of the stem for bearing on the disc.

Stop valves of this type are designed for working pressures up to 300 lb. and temperatures up to 550 deg. F. and are built in globe and angle styles with screwed ends.

News Notes

WHEN THE ANNUAL CONVENTION of the National Industrial Advertisers Association is held on October 13 and 14 at the Edgewater Beach Hotel at Chicago, the main theme will be "Reducing the Cost of Selling Industrial Products." Prominent industrial advertising and sales executives will discuss the problems involved in sale of technical and industrial products during the two day meeting.

AVERAGE DAILY production of electricity by public-utility power plants in July was 148,300,000 kw-hr., about 2 per cent less than the revised figures for the daily output of the month of June. The average daily total output for 1924 indicates that the output of electricity by public-utility power plants has decreased uniformly each month from April to July. Since there was no increase in the

rate of decrease in July, it probably can be stated, based on previous records, that the rate of decrease in the demand for electricity which has continued so uniformly so far this year probably reached a minimum in July and that the figures of output for August will probably show an increase.

MANUFACTURE and development of machinery and process of reclaiming the combustible fuel in ashes has been taken up by the Ash Reclaiming Machinery Corporation, 347 Madison Ave., New York City, of which Sterling H. Bunnell is vice-president. The principle of operation of the system was explained in the issue of September 15, on p. 964. The process is now being applied in a number of plants in this country.

OHIO MATCH CO., Spokane, Wash., has completed the installation of a 24 by 30-in. 640-hp. Corliss non-releasing Chuse engine direct connected to a 500-kv.a. Westinghouse alternator. The boiler room is equipped with four Wickes vertical water tube boilers of 225 hp. each, installed in 1923.

EDWARD L. DONAN, local manager of the Arkansas Light and Power Co. at Stuttgart, Ark., was instantly killed on Aug. 11, when he came into contact with the wire of a high voltage transmission line. Mr. Donan was a graduate electrical engineer from Washington University at St. Louis, Mo., and had been employed by the Arkansas Light and Power Co. for the last 5 yr.

MANNING, MAXWELL & MOORE, INC., of New York City have appointed P. M. Brotherhood as consulting engineer for the company. Frank J. Baumis has been made vice-president in charge of the machinery and Augustus Wood is now works manager of the Putnam Machine Co. at Fitchburg, Mass.

THE GENERAL ELECTRIC CO. is installing in the Jamestown, N. Y., Municipal plant a new 5000-kw. turbine which will be in operation this year. Added to the 4000 kw. capacity this will give a plant rating of 9000 kw. J. C. Neville is chief engineer.

JAMES T. SMITH, who has for the last 5 yr. been chief engineer for the Arkansas Light and Power Co. at Paragould, Ark., has accepted the position of chief engineer for the Arkansas-Missouri Power Co. at Blytheville, Ark.

ROCHESTER GAS & ELECTRIC CO., of Rochester, N. Y., is remodeling and extending its power plant by the installation of three 875-hp. boilers fired by Taylor stokers with steam ash dump.

W. C. MABREY, who for the last 12 yr. has been a chief engineer in the U. S. Navy, has accepted the position of chief engineer for the city water and light plant at Jonesboro, Ark.

ARTHUR L. HERRICK has been appointed sales manager of the Frederick Iron & Steel Co. Mr. Herrick was formerly connected with the Cameron Pump Works and Ingersoll-Rand Co.

SESSIONS ENGINEERING CO. of Chicago, has opened a Western district office at Portland, Ore., Suite 1238, Northwestern Bank Building, in charge of H. F. Winte.

SNOW STEAM PUMP CO. are installing a new 8 million gallon pump at the city water works of Dunkirk, N. Y. Warren Peck is superintendent.

Catalog Notes

TAYLOR STOKERS of the new type are covered in a 54-page bulletin, which is now being distributed by the American Engineering Co. of Philadelphia. The bulletin describes, in considerable detail, the various design and operating features of this stoker, and is completely illustrated to make the text matter easily understood. A large cross-sectional view is shown and the functions of the various parts are described with reference to this drawing. In the last part of the bulletin a list of representative Taylor stoker installations is presented, together with typical cross section views of different types of boilers equipped with these stokers.

PRESSURE FILTERS for clarifying water for steam boilers, textile mills, paper mills, laundries, hotels and other such services are described in a 36-page catalog, issued by the Cochrane Corporation of Philadelphia. The filtering medium employed is graded quartz-sand and gravel, superimposed in layers and increasing in size towards the bottom from which the water escapes through special strainer heads. Considerable information is given on the different classes of service for which these filters are adapted, and various drawings show the general method of installation.

ILLINOIS CHAIN GRATE STOKERS, the third edition of Catalogue L of the Illinois Stoker Co., Alton, Ill., has just been issued. In addition to describing the mechanical and operating details of this line of chain grate stokers, quite an array of blueprint drawings shows the use of both forced and natural draft chain grates in connection with all the principal types and makes of boilers. These drawings give an interesting picture of the wide variety in applications which can be handled with this type of equipment.

POWER AT LESS PER BARREL is a 16-page booklet which emphasizes the economy of the oil engine as a source of power in flour mills. This booklet is published by the Fairbanks-Morse Co., of Chicago, and shows the application of the company's type Y oil engine, built in sizes from 10 to 300 hp. as applied to flour mill service.

CATALOGUE NO. 27 of the Stephens-Adamson Mfg. Co., of Aurora, Illinois, covers chains, sprockets and gears, which are manufactured by this organization. The technical discussion is presented in conjunction with dimension drawings and price lists, in such a way as to make an interesting reference work on the subject.

APPARATUS FOR MEASURING CONDUCTIVITY OF ELECTROLYTES is the title of Catalogue No. 48, published by the Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. Apparatus of the type described may be used to determine the purity of water and hence has an application in condenser and boiler work.

NATURAL DRAFT UNITED STOKERS is the title of a new bulletin issued by the United Stokers Co., of La Porte, Ind. Operating features of this line of chain grate stokers are illustrated and described and typical cross section views of boiler installations using these stokers are shown.

A FEW OF THE PRODUCTS of the Ross Heater & Mfg. Co., of Buffalo, are described in a folder which has recently been issued. Heat exchangers, surface, low level jet and barometric condensers, strainers and expansion joints are covered.